FIRST LESSONS

ON

NATURAL PHILOSOPHY.

PART SECOND.

HARTFORD:
WILLIAM J. HAMERSLEY,
PUBLISHER.


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FIRST LESSONS

ON

NATURAL PHILOSOPHY,

FOR CHILDREN.

In Two Parts.

PART SECOND.

BY MARY A. SWIFT.

NEW EDITION, ENLARGED AND IMPROVED.

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C Hatfield

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Preface.

THE favorable reception given to the "FIRST PART OF LESSONS ABOUT NATURAL PHILOSOPHY," encouraged the writer to offer to parents and teachers of primary schools, the "SECOND PART."

It was received with the same approbation extended to its predecessor, and is now respectfully presented in an enlarged and improved form.

[illegible]

This [illegible] in an enlarged and improved form.

Lesson First.

WHAT *does Natural Philosophy teach us?*

It teaches us about the matter that all bodies are made of, and about the properties of bodies.

What is a BODY?

A body is any thing made of matter.

You have learned about the Attraction of Cohesion—is this property found in all bodies?

It is; but it is stronger in some bodies than it is in others.

In what bodies is it the strongest?

In *hard* bodies.

Do we call hard bodies by any other name?

We call them *solid* bodies, or *solids.*

Can you mention some solid bodies?

Wood, and stone, and iron are solid bodies.

Are cork and sponge solid bodies?

They are.

But they are SOFT *bodies—are* SOFT *bodies solids?*

They are.

Why are some solids HARD, *and other solids soft?*

Because the attraction of cohesion is stronger in hard bodies than in soft bodies.

What do you mean by the attraction of cohesion?

The attraction of cohesion is the power of sticking together, which God has given to the little particles of bodies.

If you make clay and dough into any shape, why will they remain in that shape?

Because they are *solid* bodies.

Why could you not make milk and oil into any shape?

Because they are *not* solid bodies.

What are they called?

They are called *Liquids.*

If I should place a solid and a liquid upon a table, how could you tell which was the SOLID?

The solid would remain upon the table as you placed it.

What would the LIQUID *do?*

It would flow on the table, or down from the table to the floor.

Why would the liquid act so differently from the solid?

Because the attraction of cohesion is so much stronger in the solid, and keeps the particles close together.

Do the particles of liquids attract each other at all?

They do.

How do we know they do?

If I dip my finger in a liquid, when I take

it out, a drop will stay on the end of my finger.

What makes the shape of drops of rain and dew?

The attraction of cohesion, that draws together the little particles of water.

What is a LIQUID?

A *Liquid* is something that *flows* like water.

Have liquids any other name?

They have; they are sometimes called *Fluids.*

Do all FLUIDS *flow like water?*

Not all; there are some fluids that are different from water and oil.

Are steam and air solids?

They are not.

How do you know they are not?

Because they do not keep their place, and can not be made into any shape.

Are they liquids?

They are not.

How do you know they are not?

Because they do not flow down to the ground, like water.

What are such bodies as air and steam called?

They are called *Aeriform* fluids.

What is the meaning of AERIFORM?

Air-form.

Why is steam called aeriform?

Because it is like air.

Can you tell the difference between liquids and aeriform fluids?

Liquids only move in one direction, that is, downward, from a higher to a lower place.

How do fluids like air move?

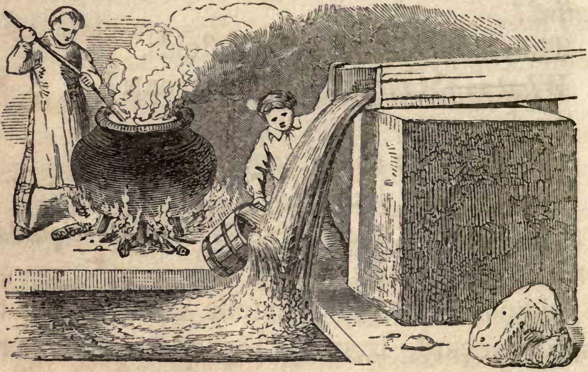
They can move as easily in one direction as in another.

What fluids do we see move upward?

The fog rises up, and helps to form the clouds, and steam rises from the engine and floats away.

How is it with smoke?

Smoke rises from the chimney, and flames rise from burning bodies.



How many kinds of fluids are there?

Two; liquids and aeriform fluids.

Then how many kinds of BODIES *are there?*

Three; solids, liquids, and aeriform bodies.

What do we call HEAVY *solid bodies?*

We call them *dense* bodies.

What is DENSITY ?

Density means *heaviness.*

What bodies are dense ?

Those bodies whose particles are close together, are dense.

What causes their particles to cling together so closely ?

The attraction of cohesion.

Can you mention some DENSE *bodies ?*

Gold, and iron, and stones are dense.

Which has the greatest density, iron or wood ?

Iron has the greatest density; it is the heaviest.

What do we call light solid bodies ?

We call them *rare*, or *thin* bodies.

What is RARITY ?

Rarity is *thinness*, or *lightness.*

What bodies are RARE ?

Those bodies whose particles are *not* attracted strongly together.

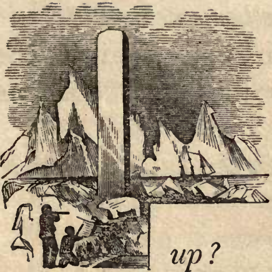
Can you mention any such bodies ?

Cork and sponge are rare bodies.

How do you know they are?

They are light, and can be cut apart more easily than iron can.

Lesson Second.



IF *you throw a hollow India rubber ball upon the floor, will it lie there?*

It will not; it will bound up into the air.

What makes it bound up?

It is full of air; and the air in it makes it bound.

Would it not bound up if it was filled with something besides air?

It would, but not near so high as it does when full of air.

Will you tell me how the air can do this?

When I throw down the ball, the side that

touches the floor is flattened or bent in, and does not leave as much room for the air inside of it.

What becomes of the air in it, then?

The particles of air are pressed together so closely that they do not take up as much room as they did before.

What presses them together so closely?

The striking of the ball against the floor, when you throw the ball upon the floor.

How long will the air in the ball stay in so small a place?

Not a moment.

What will it do?

It will instantly spring back, and press out the flat side of the ball as round as it was before.

What will the ball do then?

It will bound up from the floor.

What is the springing of the air called?

It is called *Elasticity*.

When we say the air has the power of springing back, what do we mean to say?

We mean to say that the air is *elastic.*

What other bodies are elastic?

Every body that springs back to its first shape, when it has been pressed in or struck, is an elastic body.

Can you mention some bodies that are elastic?

Ivory, wood, and many other hard bodies are elastic.

What bodies are not elastic?

Clay and wax are not elastic.

How can you tell whether a body is elastic?

By striking it against another body.

What will it do if it is elastic?

It will bound back, without seeming to be flattened or bent inward.

How will it be if it is not elastic?

It will not bound back again, but will be flattened.

How do you know that the air we breathe is elastic?

If the air *in* the ball is elastic, the air *out* of the ball must be elastic too.

When you stretch a piece of India rubber, what makes it spring back as soon as you let it go?

Its elasticity.

If you pull out the string of a bow, what will happen to the bow?

It will bend.

What if you let go the string?

The bow will straighten, as it was before.

Why will it straighten?

Because the wood of which the bow is made is elastic.

Why do you pull the string hard when you fix the arrow to it?

So that the arrow may fly the farther.

What makes the arrow fly off when you let go the string?

The bow is bent when I put on the arrow, and, the moment I let go the string, the bow springs back so quickly that it straightens the string with a jerk, and the arrow is sent into the air.

Now can you tell me what it is that makes the arrow fly off from the bow?

It is the *elasticity* of the bow.

You said the air is a fluid—then are fluids elastic?

Some fluids are.

What fluids are elastic?

Aeriform fluids are called *elastic* fluids.

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Lesson Third.

IF *you can easily bend any body you hold in your hands, as you can a piece of steel spring or a wire, what do you say of that body?*

I say it is *flexible.*

What is the meaning of FLEXIBLE?

Flexible means *easily bent.*

But if, instead of BENDING, *it should* BREAK *what kind of a body should you call it*

I should call it *brittle.*

What do you mean by a BRITTLE *body?*

I mean a body that easily *breaks.*

Mention some BRITTLE *bodies.*

Glass and china are brittle, ice is brittle, stones are brittle, and so are some metals.

What bodies are flexible?

Tin, lead, India rubber, thin plates of most metals, and wires.

Could any one hammer out, or roll out, gold and silver into thin plates?

He could, with heavy hammers or machines.

When any metal can be hammered out thinner, without breaking, what do we call it?

We call it *malleable* or *hammer*-able.

Is CHALK *malleable?*

It is not.

How do you know?

If I strike it with a hammer, it breaks in pieces, instead of spreading out thin.

Then what do you say of chalk?

I say it is *brittle.*

How thin can gold and silver be rolled out, or hammered?

Till they are thinner than paper.

What are they then called?

Gold-leaf and silver-leaf.

How thin can gold-leaf be made?

So thin that three hundred and sixty thousand leaves of it, when all laid together in a pile, would be only an inch thick.

Of what use is such thin gold-leaf?

It is used to cover looking-glass and picture frames, and to put upon wood, or leather, or paper.

When any thing is covered with gold-leaf, what do we call it?

We call it gilt or gilded wood or paper.

When a metal can be stretched out, like a wire, to a great length, without breaking, what is it that keeps it from breaking?

Its *tenacity*.

What is the meaning of TENACITY?

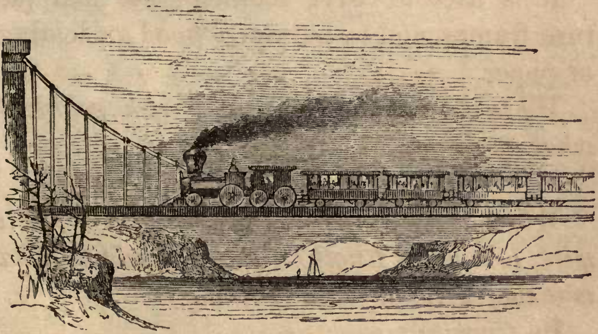
Tenacity means its power of *holding together*.

Then has WIRE *great tenacity?*

It has.

Can you tell about any thing that shows the wonderful tenacity of IRON-WIRE*?*

Very strong *bridges* are made across some rivers, for the heavy locomotive and cars to go safely across, and yet these bridges hang on *wires of iron.*



What is the name of such bridges?

They are called *suspension* bridges.

What is the meaning of SUSPENSION?

Hanging; for they hang upon the wires.

How are the wires fastened each side of the river?

A strong tower is built on each bank of the river, and the long, large wires pass over the towers, and are fastened firmly into the ground beyond.

Lesson Fourth.

WHEN *you say a body is* MOVING, *what do you mean?*

I mean that the body is *changing its place.*

Then what is the meaning of the word MOTION?

Motion means change of place.

When your ball moves along the floor, what PUTS *it in motion?*

My hand.

When the arrow flew through the air, what put it in motion?

The springing of the bow made it fly off.

Then what puts bodies in motion?

The *power* of the body that strikes, or pushes, or draws them, puts them in motion.

What is this power called?

It is called *force.*

What put the arrow in motion?

The force of the elasticity of the bow.

How do you know?

If the bow had not been elastic, the arrow would never have left the string.

What can stop the motion of a body?

The power or force of something else can make it stop.

What makes an arrow stop moving, after it has been shot into the air?

If it falls to the ground, it is the force of the attraction of gravitation that brings it down.

If it goes into a tree or a board, what force stops it then?

The force of the cohesive attraction of the particles of wood stops it

How does the cohesive attraction stop it?

It keeps the particles of wood so closely together that the arrow can not separate them.

When the wood will not permit the arrow to go through it, what do we say the wood does?

We say the wood *resists* the arrow.

Which is it that resists the arrow, the particles of wood, or the cohesive attraction that draws the particles together?

It is the attraction of cohesion.

How do you know?

If the cohesion could be taken from the wood, the arrow would pass through it.

When you throw a ball into the air, will it move all the time as fast as it did when you first threw it?

It will not, but will go slower and slower, till it falls.

When the motion of a body becomes slower and slower, what do we call such motion?

We call it *retarded* motion.

What is the meaning of RETARDED?

Any thing is retarded that goes slower and slower.

If you were running, how could you RETARD *your motion?*

By beginning to walk.

If you were walking, and should begin to run, and should continue to run faster and faster, what kind of motion would that be?

It would be *accelerated* motion.

What do you mean by ACCELERATED *motion?*

Quickened motion.

If you were walking, and should not go any faster or any slower, what motion would that be?

It would be *uniform* motion.

What is meant by UNIFORM *motion?*

Motion that is always alike, never slower or faster.

Mention some body that always moves alike.

The minute-hand of a watch, and all the wheels in a watch, move just as fast at one time as they do at another.

Then what is the motion of a watch?

It is uniform motion.

When a ball is falling to the ground, what is its motion?

It is accelerated motion.

Why is it accelerated?

Because the attraction of the earth draws it more and more, the nearer it comes to the earth, and this makes the ball fall faster and faster.

When you throw up a ball, what is its motion?

It is retarded motion.

Why is it retarded motion?

Because the attraction of the earth draws it down when my hand sends it up, and this makes the ball go slower and slower, till it finally falls to the ground.

How many kinds of motion have you mentioned?

Three.

What are they called?

Retarded motion, *accelerated* motion and *uniform* motion.

How does a body move when its motion is retarded?

Slower and slower.

How when its motion is accelerated?

Faster and faster.

How when its motion is uniform?

Neither faster nor slower, but always alike.

When you say a ball ASCENDS, *what do you mean?*

I mean that the ball goes up, or rises.

When a body DESCENDS, *what does it do?*

It goes down, or falls

What kind of motion does a body have by being thrown upward?

Retarded motion; because it rises slower and slower.

What is the motion of this body when it descends?

Accelerated motion; because it falls quicker and quicker.

What is the motion of water when it is falling in a cataract?

It is accelerated motion.

Which has the greatest weight, a cannon ball or a bullet?

A cannon ball.

If you could throw a cannon ball against a thin board, would it go through the board

It would not.

If a bullet should be shot out of a gun, would it go through the board?

It would.

Why would the bullet go through, when the cannon-ball, which is much heavier, would not?

Because the bullet goes so much faster than the ball.

What is swift motion called?

Velocity.

Then why will the bullet go through the board, when the ball will not?

Because the weight and velocity of the bullet together, is greater than the weight and velocity of the ball, when put together.

When weight and velocity are put together, what is the whole called?

The *momentum* of the body.

Which momentum is greatest, then, that of a cannon-ball thrown by the hand, or that of a bullet fired from a gun?

That of the bullet.

How could you increase the momentum of the cannon-ball?

By firing it from a cannon.

Lesson Fifth.

WHEN *you throw a ball against the wall, what becomes of the ball?*

It will bound back, as if the wall threw it back to me.

What is its motion from the wall back to you called?

It is called *reflected* motion.

What is meant by REFLECTED *motion?*

The motion made by throwing back any thing.

What is the meaning of the word REFLECT?

It means to throw back again.

Then, when I say a body is reflected, what do I mean?

You mean that the body is thrown back again.

If I should strike a ball to make it go one way, and you should strike it at the same time to make it go another way, what would its motion be called?

It would be called *compound* motion.

Why would it be called COMPOUND *motion?*

Because it would be two motions put together.

What two motions would it be?

The motion which your hand gave it, and the motion which my hand gave it at the same time.

Which way would the ball move if we struck it together?

It would not go the way your hand sent it, nor the way my hand sent it, but it would move between those ways.

In what kind of a LINE *does the ball move after being struck by both our hands?*

In a *straight* line.

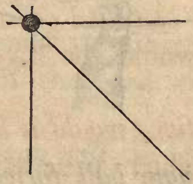
What is the motion of the ball called?

It is called *rectilinear* motion.

What is the meaning of RECTI–LINEAR?

Straight line.

Here is a diagram which will show you how the ball would move.



When you hold a string that is tied to a ball, and swing the ball round, what is the motion of the ball?

It is *circular* motion.

Why is it called CIRCULAR *motion?*

Because the ball moves round in a circle.

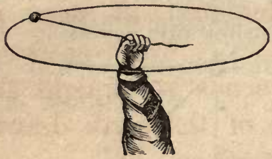
What is the motion of the earth around the sun called?

It is called circular motion.

Why?

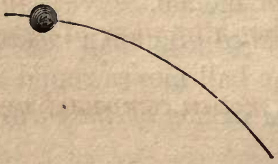
Because the earth moves in a circle around the sun.

Here is a diagram which shows you what circular motion is.



If you throw your ball forward, will it fall down to the ground in a straight line?

No; it will make a curved line, like the diagram.



What then is the motion of the ball called?

It is called *curvilinear* motion.

What is the meaning of CURVILINEAR?

Curved line.

Then what is curvilinear motion?

Motion in a curved line.

What makes the ball move in a curved line?

My hand sends it straight forward, and the attraction of the earth draws it straight down.

Then which way will the ball move?

It can not go either way, but goes between.

Then is curvilinear motion compound motion?

It is.

Why?

Because it is the motion made by my hand and the attraction of gravitation together.

Is circular motion compound motion also?

It is.

Why?

Because it is made by throwing the ball into the air, while at the same time you keep it from going off by holding the string.

Why is one kind of compound motion RECTILINEAR *and another* CURVILINEAR?

When both of the hands or forces are taken away *as soon as* they have struck the ball, it will move in a *straight* line.

Then what motion will the ball have?

Rectilinear motion.

How will it be, when one force continues to move the ball after the other is removed?

The motion will be in a curved line, or curvilinear.

When you throw a ball straight forward, what force continues to move the ball after it leaves your hand?

The attraction of the earth draws it to the ground in a curved line.

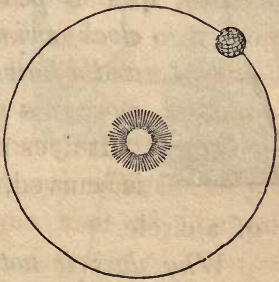
How is the circular motion of the earth compound motion too?

The *centrifugal force* makes it go from the

center, and the *centripetal force* draws it to the center.

To what center?

The sun; because the earth moves round the sun.



Lesson Sixth.

WHEN *a pendulum to a clock swings backward and forward, does it move in a straight line?*

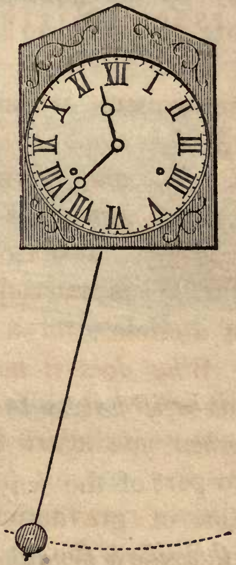
It does not; the line is curved, like a part of a circle.

Why does it not swing quite around the place where it is fastened, just as the ball does when you whirl it round your hand?

The attraction of gravitation draws the pendulum down toward the ground when it begins to go up.

Then why does not the pendulum stop, instead of going up the other side?

Because it goes down so fast that it can not stop in an instant.



What is this like?

Like a boy sliding down hill.

How does he go?

He goes so fast down the hill, that when he gets to the bottom he can not stop, but goes part way up the next before the sled stands still.

How would it be, if he should slide down the second hill?

He would go part of the way again up the first.

And how is this like a pendulum?

When my hand draws aside the pendulum, and then lets it go again, the attraction of gravitation draws it down as far as it can;

and, because it can not stop itself, it will go up the other side.

What will it do then?

The earth will draw it down again so fast, as to send it up the side from which it started.

What is a favorite amusement of the Russians?

Sliding down ice-hills.

How is an ice-hill made?

It is made of wood, covered with water frozen to ice; it has three ascents, one above another, with a little valley between each ascent.

How do they slide down this ice-hill?

At the top of the hill they seat themselves on a sled made for the purpose, and slide down the first ascent very swiftly.

Will the sled stop there?

It will not.

Why will it not?

Because it came down so fast, that it will

slide across the little valley and up to the top of the next ascent; and then down that, in the same manner.

What keeps a pendulum of a clock in motion all the time?

The wheels that are inside of the clock.

What makes the wheels move?

The weights that draw the strings that are fastened to the wheels.

How long will the pendulum swing before it stops?

Till the wheels stop moving.

How long will the wheels move around?

Till the weights reach the bottom of the clock.

How can they be put in motion again?

By winding up the strings that fasten the weights to the wheels.

What makes the weights go down to the bottom of the clock?

The attraction of gravitation.

What is the attraction of gravitation?

The attraction of the earth.

Then, when a clock goes, what does the attraction of gravitation do to make it go?

It keeps the wheels in motion, and thus helps to keep the pendulum swinging.

How fast does a pendulum commonly swing backward and forward?

Once in every second, which would make sixty times every minute.

Can any thing be made to move forever without stopping?

No, nothing.

Has any one ever tried to make a body move forever?

Yes; many have tried, but they could not do it.

If a body should move forever, what would its motion be called?

Perpetual motion.

What is the meaning of PERPETUAL?

Perpetual means never-ending.

Then what is perpetual motion?

Never-ending motion.

How many motions have you learned about?

Eight.

What is the first?

Retarded motion, or motion that becomes slower and slower, as if a boy stopped running and began to walk.

What is the second?

Accelerated motion, or motion that becomes faster and faster, as if he began to run again.

The third?

Uniform motion, or motion that is always alike, like a clock.

The fourth?

Reflected motion, or moving back again like a ball bounding back from a wall.

The fifth?

Compound motion, or two motions together.

The sixth?

Circular motion, or motion in a circle, like swinging a ball tied to a string.

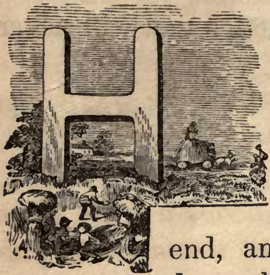
The seventh?

Curvilinear motion, or motion in a curved line.

The eighth?

Perpetual motion, or motion that will never stop.

Lesson Seventh.



How *do children play at* SEE-SAW?

They take a plank of wood, and lay it across a block or a fence, and then one sits on each end, and they swing up and down the see-saw.

What is a plank sometimes called?

It is called a *lever.*

What is a lever?

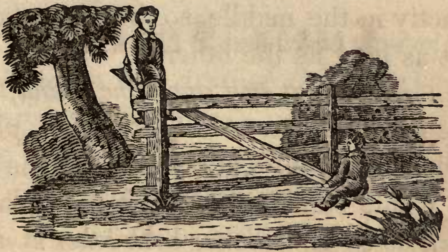
A rod or plank that will not bend easily is a lever.

What is the block that it rests upon called?

It is called a *fulcrum.*

What is a fulcrum?

That which the lever or plank stands upon, when its ends are moving up and down.



If the plank were laid across a fence, when you play at see-saw, what would be its fulcrum?

That part of the fence that it lies across.

What are the parts of the lever each side of the fulcrum sometimes called?

They are called *arms* of the lever.

Then, if you were playing at see-saw, where would the arms of the lever be?

I should sit on one arm of the lever, and my companion would sit on the other arm.

If you are just as heavy as your companion, where must the block, or the fulcrum of the plank, be placed?

Exactly in the middle, so that one arm may be just as long as the other.

Then, if you sat still upon the plank, would it move up and down?

Each arm would exactly balance the other, and it would stand still.

When do bodies balance each other?

When one is just as heavy as the other.

If your companion is twice as heavy as you are, how must the plank be placed on the fulcrum?

So that the arm on which I sit may be almost twice as long as hers.

Where would the fulcrum be, then?

Near my companion.

What POWER *sets the lever in motion up and down?*

We are the power; because I strike my feet on the ground, so as to send myself up,

and that makes my companion go down; and then she does the same, and goes up while I go down.

If a stone much heavier than yourself should be placed on one arm of the lever, how could you raise up the stone?

By putting the fulcrum so near it, that the arm on which the stone lies would be very short, and the other very long.

Would you have to use much strength to raise it, then?

I should not, if the long arm was very heavy.

Why would you not?

Because the long arm would be so heavy, that it would almost raise the stone on the other arm of itself.

Then what is the use of the lever?

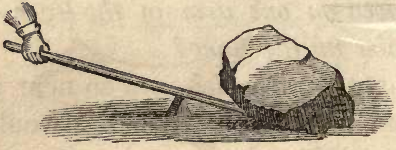
It assists us in raising large and heavy bodies.

In raising the stone, what was the power?

My hand.

What was the weight?

The stone.



What was the fulcrum?

The block upon which the lever rested.

Where was the fulcrum placed?

Between the power and the weight, or between the hand and the stone.

Is a pair of scissors like a lever?

Yes; it is two levers, fastened together.

Do both levers move the same way?

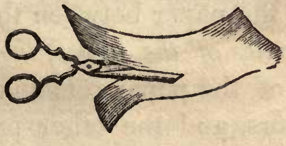
No; when one moves up, the other goes down, till they meet together.

What is the fulcrum of each lever?

They both have the same fulcrum.

What is it?

Each lies across the other, and they are fastened together, where they cross, by a small rivet or screw that goes through them.



Then what is the fulcrum of the scissors?

The rivet that fastens the scissors together.

What is the power that moves these levers?

My hand.

What is the weight?

If I am cutting paper, the paper is the weight.

Will you tell me why the paper is the weight?

Because, when I am cutting it, I lift up the paper with the lever which my thumb draws

down, and I press down the paper with the lever which my fingers draw up.

How will this cut the paper?

The levers are screwed so tight to each other, that when they come together there is no room for the paper between them.

What becomes of the paper, then?

One part of the paper remains on one side of the scissors, and the other part is on the other side, and the scissors are between them.

Then what have the scissors done to the paper?

They have *divided* it.

Are the scissors the same kind of lever as the see-saw?

They are.

How do you know they are?

Because, in them both, the power is at one end, the weight at the other, and the fulcrum between.

Lesson Eighth.

WHEN *a merchant weighs out a pound of sugar, how does he do it?*

He takes a pair of scales, or balances, like those in this picture, and puts a piece of lead, that weighs exactly a pound, into one of the scales.

Then what does he do with the sugar?

He puts just as much sugar into the other scale as will lift up the weight in the first scale.

How can he tell when he has put in a pound of sugar?

When one scale is just as heavy as the other, then the sugar is weighed right.

Are these scales like a lever?

Yes, they are a lever.

Which is the fulcrum?

The place where they are hung up is the fulcrum.

What is the weight?

The lead in one scale.

What is the power that raises the lead?

The sugar in the other scale.

Then, is not the lever very useful?

It is; it would be very difficult for us to do many things without the lever.

Lesson Ninth.

WHEN *you open a door, which is the weight that you move?*

The door is the weight.

What is the fulcrum?

The hinges are the fulcrum.

What is the power?

My hand.

Is the door such a kind of lever as the see-saw?

It is not.

Why is it not?

Because the weight is between the power and the fulcrum.

How is it with the see-saw?

The fulcrum is between the power and the weight.

Is there any other kind of lever?

There is one more.

What is it?

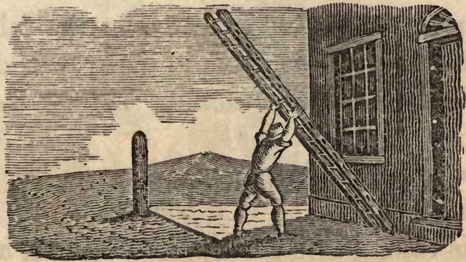
It is a lever which has the power between the weight and the fulcrum

Have you ever seen such a lever?

Yes; when I have seen a man raising a ladder against the wall.

What was the fulcrum?

The ground, on which the bottom of the ladder rests.



What the weight?

The ladder.

What was the power?

The strength of his hands.

Then how many kinds of levers are there?

Three kinds.

What is the first?

One where the fulcrum is between the power and the weight—as the see-saw.

What the second?

One where the weight is between the power and the fulcrum—as the door.

What the third?

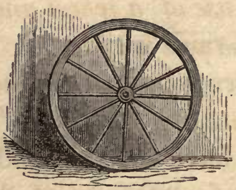
Where the power is between the fulcrum and the weight—as a man raising a ladder.

What is another means of raising weights besides the lever?

The wheel and axle.

What is the shape of a wheel?

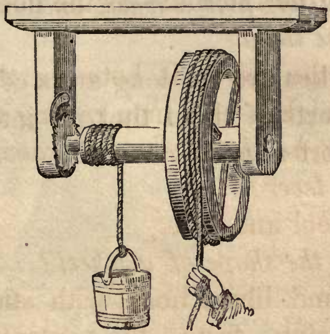
It is round, like a hoop, with sticks, called spokes, going from the outside to the center.



What is the axle of a wheel?

The place where the spokes are fastened in the center of the wheel.

Here is a picture of a wheel and axle.



What is the use of a wheel and axle?

It is used to raise weights.

Have you ever seen a wheel and axle used in raising a weight?

Some wells have a wheel and axle to raise up the bucket of water out of them.

How is it done?

The rope or chain on which the bucket hangs is fastened to the axle, and so, when

the wheel turns around, the rope winds around the axle till the bucket comes up.

Can you tell how a wheel and axle is like a lever?

The spokes are the long arms of the lever, and the parts of them that go into the axle are the short arms.

Lesson Tenth.

WHY *will a ball roll down upon the floor, if you place it upon a desk?*

Because the desk is not level, like a table, but inclines downward.

What may a desk then be called?

An *inclined plane.*

What is a plane?

A smooth surface.

What is an INCLINED PLANE*?*

A smooth surface, that slopes or inclines downward.

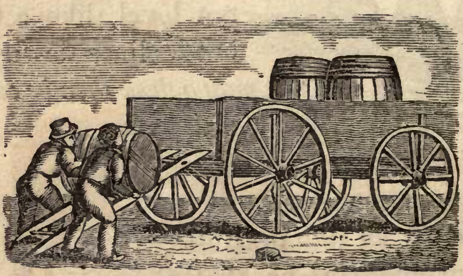
What is the use of an inclined plane?

It is used to raise weights.

How is a weight raised easier by an inclined plane than without it?

If we put one end of a long board upon a wagon, and let the other rest upon the ground, and roll a barrel up the board into the wagon, we shall find it much easier than it would be to lift it straight up from the ground into the wagon.

Here is a picture of an inclined plane, with a weight rolling up upon it.



What is the shape of the blade of a knife?

It is like two inclined planes, put together.

What would the blade of a knife be called in Philosophy?

It would be called a *wedge.*

What is a WEDGE?

It is like two inclined planes, put together, so as to have a sharp edge on one side, where they meet.

Here is a picture of a wedge in a log.

Of what use is a wedge?

A wedge is used for cutting or dividing things.

Mention the names of some wedges.

A knife is a wedge, and so is an axe, and almost all cutting instruments are wedges.

Have you ever seen a screw?

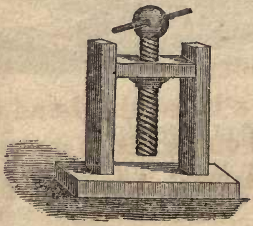
I have, very often.

Where have you seen them?

A pair of scissors is fastened together with a little screw, and hinges and locks are fastened upon doors with screws.

Why are not nails as good as screws to fasten them with?

A nail might be pulled out; but the sharp edge, that rises and winds around the screw, keeps it in tight, just where it is fastened.



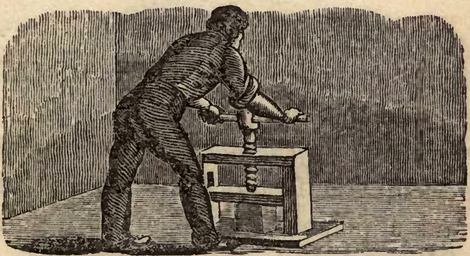
What is a screw like?

It is much like a round nail, with a sharp wedge wound around it.

Of what use is the sharp edge or wedge around the screw?

It cuts the wood where it goes in, while we are turning it, and holds the screw in its place.

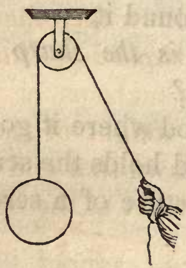
Here is the picture of a screw.



What is a PULLEY?

A pulley is a little wheel and axle, with its edge hollowed out, so as to make a place for a cord to wind around it.

Here is one, with a cord upon it.



Of what use is a pulley?

Weights are raised by means of pulleys, and removed to other places.

How do they help people to raise weights?

The weight is fastened to one end of the cord, and a person can raise the weight by pulling down the other end of the cord.

How are buckets of water sometimes raised out of a well?

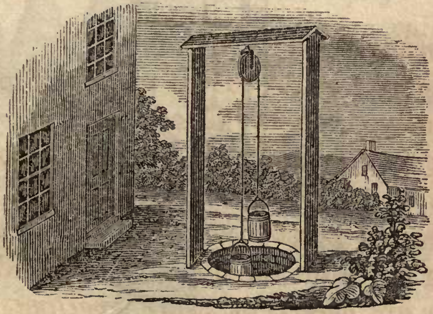
A rope is put over a large pulley, that is fixed above the well, and a bucket is fastened to each end of this rope.

When one bucket is filled in the well, how is it easily brought up?

By drawing down the other bucket.

Why does it require so little strength to do this?

Because the weight of the empty bucket helps to draw down that end of the rope, and raise the full bucket at the other end.



How many kinds of pulleys are there?

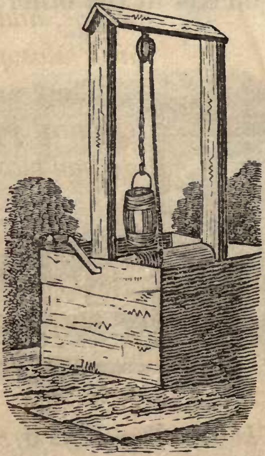
Two; the *fixed* pulley and the *moveable* pulley.

What is a fixed pulley?

A pulley that turns round, but remains fixed in the same place.

What is a moveable pulley?

A pulley that is constantly moving from some place, as it turns round.



Lesson Eleventh.

WHAT *are the lever, wheel, pulley, inclined plane, wedge, and screw called in Philosophy?*

They are called *mechanical powers.*

What do you mean by mechanical powers?

The power of *machines* or instruments.

Of what use are the mechanical powers?

They help us to raise and move very large weights, and to divide and cut hard bodies into any shape we please.

Can you mention some useful machines?

Clocks and watches, locomotives and steam engines, are useful machines.

Of what use are steamboats?

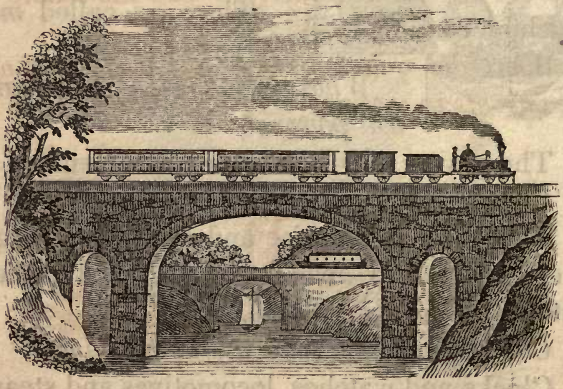
They carry very heavy loads of goods and people across the water, much faster than vessels can.

How can they do this?

By means of the machinery in them.

What keeps the machinery in motion?

The power of the steam.



How can the cars on railroads move so very rapidly?

It is by means of the power in the locomotive engine, that draws them.

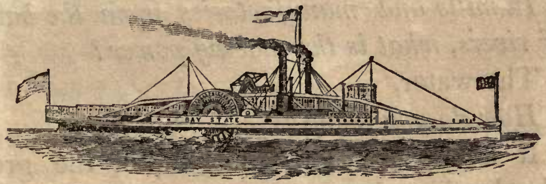
Does steam keep these machines in motion?

It does.

What do you mean by MACHINE *or* MACHINERY?

When several instruments or mechanical powers are put together, we call the whole a machine or machinery.

What did you say kept the machinery of steamboats in motion?



The power of the steam.

What is steam called when it moves machinery?

It is called a *moving power.*

Then what is the moving power of steamboats?

Steam.

What is the moving power of railroad cars?

Steam.

What is the moving power of a clock?

Gravitation.

How do you know?

It is gravitation which draws down the weights, that turn the wheels, and keep the clock going.

In mills and manufactories upon the banks of rivers, what is the moving power?

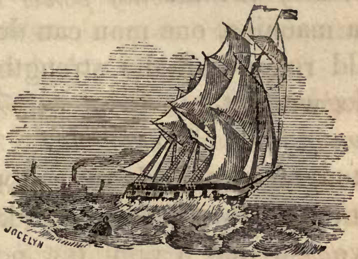
The water.

How do you know?

It is the water running upon the great wheels that keeps them turning; because, when the stream is very low, or almost dry, the wheels stop turning.

Is water the moving power of all mills?

No; the moving power of some mills is wind.



What are such mills called?

Windmills.

When animals or men move machines, what do we say the moving power of such machines or instruments is?

Animal strength, or the strength of men and animals, is their moving power.

Who has provided the moving powers of all machines?

The Creator of the world.

What good have they done for man?

They save him from much very hard labor.

How do they do this?

With a machine, one man can do the work that would require all the strength of many men to do, without it.

Can you mention one example?

In cotton factories, where cotton cloth is made, they have machines to card, and spin, and weave; so that a very few persons can make hundreds or thousands of yards of cloth in a day, from cotton that is brought in, the same morning.

Can you mention another example?

On railroads, a little steam-engine can draw

a great many heavily loaded cars thirty miles in one hour.

Who teaches man how to save his labor by contriving these machines?

Our Creator.

How does he teach us?

He made the wood and iron of which machines are made; and the wind, and water, and strength, that moves them; and He teaches the mind in us to think and contrive how to use these things.

Can you describe a machine so curious that it could never have been made without a great deal of thinking and contriving?

A man in England made two clocks, and sold them to some gentlemen, who sent them as a present to the Emperor of China. Each clock was in the shape of a little chariot. A very small *lady* sits gracefully in it. Her right hand is leaning upon the chariot. Under her hand is a curious little *clock*, about as large as a quarter of a dollar. This clock strikes

every hour, and will go eight days without being wound up. Upon the lady's finger sits a beautiful little *bird*, adorned with diamonds and rubies. Its tiny wings are spread out ready to fly, and if a diamond button below it is touched, the bird will flutter for some time.

What makes the bird move?

Its little body is full of very small wheels, which make it move.

How large is the whole body of the bird?

About the size of a *pea.*

Can you tell any thing more about the clock-chariot?

The lady holds in her left hand a gold tube, no larger than a large pin. On the top of this tube is a small round box. Around this box is a ring, made with gold and diamonds, not larger than a ten cent piece. This ring goes round and round the box, three hours at a time without stopping.

Can you tell what is over the lady's head?

There are two small *umbrellas*, standing

upon a pillar no larger than a quill. Under the largest umbrella is a little *bell*, which strikes every hour. At the lady's feet is a golden *dog*, and before it are two little *birds*, fastened upon springs. Their wings and feathers are very brilliant with precious stones, and they seem to be flying away with the chariot.

How can the chariot move along?

By means of springs and wheels, that are out of sight. If they are touched, they can make the chariot go straight forward, or in a circle, or in any way that you wish.

What is behind the chariot?

A little golden *boy*, taking hold of it, and seeming to push it along. Above the umbrella are *flowers* and *ornaments* of precious stones; and at the top of the whole stands a little *flying dragon*, made of the same brilliant stones.

What good lesson should we learn from this story?

That the man who made these wonderful *clocks* had great *skill;* and that God, who made the man, and gave him so much skill, must be more skillful than all the men in the world—*more skillful than we can think.*

Lesson Twelfth.

WHICH *would a sled slide down most easily, a hill of sand or a hill of ice?*

The hill of ice.

Why would it slide most easily over that?

Because sand is rougher than ice.

Then does the roughness of the sand hinder the sled from sliding down?

It does.

What is the name that philosophers give to this roughness, when bodies are rubbing against each other?

They call it *friction.*

Which can you turn most easily, a rusty lock or a bright one?

The bright one.

Then, which lock has most friction?

The rusty one.

Why will a person slip down upon ice, and not upon stone or earth?

Because there is more friction when his feet rub against the stone than when they rub against the ice.

How could the rusty lock be made to turn as easily as a bright one?

By oiling it.

Why would oiling it make it turn easily?

It would take away some of the friction.

How would it take away the friction?

By making the iron smooth.

Can you mention another example of friction?

I have heard carriage wheels creak, because they needed greasing at the axle.

Why do people grease carriage wheels?

To make them smooth, and turn easily around the axle.

Why will the grease make them turn easily?

It destroys some of the friction.

Why do drivers of carriages, when going down steep mountains, fasten one of the wheels, so that it can not turn?

To increase the friction of the wheel, and prevent the carriage from going down so fast.

What does INCREASING THE FRICTION *mean?*

Making it more difficult for the wheels to go down hill.

How many kinds of friction are there?

Two.

What are they called?

The *dragging* and the *rolling* friction.

Can you mention an example of dragging friction?

The chained carriage wheel, dragged down the hill.

What is an example of rolling friction?

Wheels, when they are turning or rolling.

When the walks are covered with ice, why is it difficult to walk upon them without slipping?

Because there is not friction enough.

What would happen to us if there were no friction?

We could not walk a step before we should begin to slip along very fast, and could not easily stop ourselves.

How do people increase the friction when the walks are covered with ice?

They throw sand, or ashes, or something rough, upon them.

Could you hold any thing in your hand if there were no friction?

Not without difficulty.

Why?

Because it would slip through so easily.

Then, is not friction very useful?

It is; for I could not hold my knife and fork, or book, very easily, without friction.

How do people travel from Mount Cenis, in Europe, to the town of Laneburg?

On the top of the steep, snowy precipice the traveler gets into a sledge, and slides down so swiftly, that he goes three miles in seven or eight minutes, and his breath is almost taken away from him by the motion.

What makes him go down so fast?

The ice is so smooth that there is scarcely any friction when the sledge glides over it.

Why is it much easier to travel and to carry heavy loads upon snow than upon the ground?

Because the snow is so very smooth, that the friction is almost destroyed, and the runners slide along more easily than wheels roll along the ground.

Lesson Thirteenth.

D*o you recollect what you learned about springs?*

I learned that they were made by the water, under ground, bursting out at the top.

When a spring bursts out a little while, and then stops, and then goes on again, and continues stopping and going on, what is it called?

It is called an *intermitting* spring.

What is the meaning of INTERMITTING?

Any thing that sometimes goes and sometimes stops is called intermitting.

Can you tell what is the cause of intermitting springs?

They stop or intermit, at times, because

there is not always enough water under the ground to keep them running.

Why are not all springs intermitting springs?

Because some basins are so large that they are never empty, from one rain to another.

Does the rain make all springs?

It does not.

What besides rain causes springs?

The springs which are near those mountains that are always covered with snow, are made by the melted snow.

What would become of the water that flows from the springs, if there should be mountains and hills all around them?

They would fill up the valley between the hills, and this would form a *lake.*

Where would the water go, when the valley was filled up with it?

It would flow out of the first opening it could find, and become a river.

What can you tell about Lake Geneva.

The river Rhone ran down from the mountains, till it came to this valley made by the high hills all around it, and there it stayed till it had filled it and found an opening, and then the river ran on to the ocean.

What is this valley full of water called now?

Lake Geneva; and it is a beautiful lake, among the mountains of Switzerland.

Then what is a lake?

A valley full of water.

Are lakes always full of water?

They are not always; some are dry part of the year.

Can you mention any?

Lake Merom is such a lake, in Palestine.

What can you say of lake Merom?

It is a small lake, made by the river Jordan. When the snows on Mount Lebanon melt, and run down in the Jordan, this lake is full, and is several miles long; but, when the hot weather comes on, it dries up.

Do you know of any other such lake?

In Germany there is one called Zirknitz (pronounced Tzeerkneetz,) lake.

Will you describe it?

It is four or five miles in length, and about two miles wide. All around it are wooded mountains, in which live deer, wild boars, and hares. A part of the year the people come here in boats to fish, and the other part they may sow and reap grain, and hunt these animals, at the bottom of the lake.

Can you tell about a very curious way of fishing these people have?

When the water goes out of the lake, it runs through about forty holes at the bottom, carrying the fish with it. This makes so many little whirlpools. When the water has all run through, the peasants go down with lights into one of these cavities. This cavity or hole is several feet under the bottom of the lake, in a solid rock. Here the water runs down again, through small holes, as

through a seive, and the poor fishes are left behind for the peasants to catch

Can you mention any more remarkable accounts about this lake?

Sometimes, when it begins to rain hard, three of these cavities spout up water to the hight of twelve or eighteen feet. If the rain continues, the water will bubble out of the holes through which it had run, and the whole lake will fill again in a single day.

Lesson Fourteenth.

WHAT *very remarkable lake do you read of in the Bible?*

Lake Asphaltites, or, as it was often called, the *Dead Sea.*

What do you know about this lake?

It is supposed to have been caused by the destruction of Sodom and Gomorrah.

How does it differ from other lakes?

The water in it tastes salt, and different from sea-water.

What is found mixed with the water, to give it such a taste?

Salt, and magnesia, and bitumen.

What is bitumen like?

It looks like hard coal, and burns like tar.

Do you know of any other wonderful lake in Asia?

In the northern part of Asia is a large lake, which throws up a liquid, which the people collect, and put in their lamps to burn.

Are there any springs in the world that throw up such liquids?

In Italy there are *oily* springs.

What can you say of them?

Their surfaces are covered with oil, that smells very fragrant when it is burning, and is of different colors.

How much oil is collected from some of these springs?

From one spring, near the Appenine mountains, which comes out of a rock, people can collect *twelve pounds* in one week.

What is the name of this rock oil?

Petroleum.

What is the meaning of the word PETROLEUM?

Petre means *rocks*, and *oleum* means *oil.*

Why is it called rock oil?

Because it comes up from rocks.

Is this oil ever found upon the sea?

It is found in the sea, near mount Vesuvius.

How does it first show itself on the water?

While it is rising to the top of the sea, the water seems to be covered with bubbles.

How do people gather it?

They skim it off, as they sit in their boats, and then put it into pots and jars.

Does this petroleum rise to the top of the water all the time?

It rises only in warm weather.

What different colors has the oil?

Some is white, some yellow, some red, and some black.

Which oil is the best?

The white, clear oil.

Which is poorest?

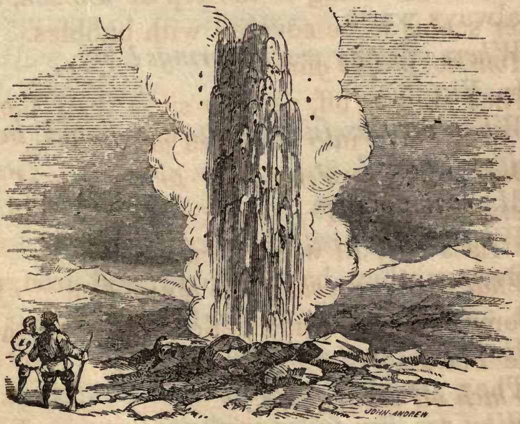
The black; because it is not pure.

Are there any springs of petroleum in this country?

There is one in Kentucky.

Do you know of any other kinds of springs, besides the oily springs, and springs of good water?

In Iceland there are *boiling* springs.



Why are they called boiling springs?

Because they are as hot as boiling water.

Are they of any use to the people of Iceland?

The Icelanders boil and cook their food with them.

What other springs have you heard of?

Warm springs.

Why are they called warm springs?

Because the water that comes up from them is always warm.

Where are any warm springs?

In Virginia.

What very useful springs are found in the United States?

Mineral springs.

Why are they called mineral springs?

Because they have sulphur, and iron, and salt, and other minerals in them.

Have they any different name?

They are often called *medicinal* springs.

Why are they called medicinal springs?

Because they cure diseases, as medicine does.

Can you mention the names of some of these springs?

There are Ballston and Saratoga Springs, in the State of New York, and Yellow Springs, in Ohio, and many others in different States.

What curious springs are sometimes found in the sea, near the shore?

Springs of *fresh* water.

How can it be got, without mixing it with the salt sea-water?

A bottle, corked tight, can be let down directly over the spring, and, when it is low enough, the cork can be drawn out, and the fresh water will instantly fill the bottle, which can then be drawn up.

What are HOT *springs?*

Those whose water is always hot.

What are COLD *springs?*

Those springs which are very cold, in warm and cold weather.

What becomes of the water that rises from springs?

It runs into streams and rivers.

Where do the rivers carry their water?

Into lakes and seas, and into the ocean.

Does the water of springs always run into rivers or lakes?

Not always; sometimes it disappears, before it can get to a river.

What becomes of it?

Sometimes it is turned to vapor, by the heat of the sun.

What do we say of water, when it is turning into vapor?

We say it is *evaporating.*

Does the water of springs ever disappear in any other way?

It sometimes sinks into the earth, as the water of some lakes does.

Can you tell me of one such spring?

In Palestine, near mount Lebanon, there is a spring called *Phiala*, because it looks like

the mouth of a vial; and the water from this spring goes down into the ground.

Has any one ever found out what becomes of it under ground?

In the life-time of Herod the Great, the spring, and a stream that came out of the ground thirteen miles from this spring, were examined.

How did people examine them?

They knew that wood floats upon the top of water; and they threw some wood into the spring, and it went down into the ground.

Was it ever seen again?

The people, who were watching the stream that came out of the ground thirteen miles south of the spring, after looking some time, saw those very pieces of wood come out in it.

What did this prove?

That this stream ran under ground thirteen miles.

What is the name of this stream?

It is the river *Jordan*, that we read so much about in the Bible.

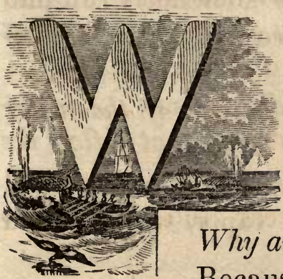
What do you learn from this river about streams that disappear?

That such streams do sometimes run into rivers and lakes, when we think they evaporate.

What bad effect would happen if the water was not carried off out of a lake.

The water would become very bad, and fill the air with a dreadful vapor, which would make people sick.

Lesson Fifteenth.



WHEN *the wind passes over stagnant lakes or pools, and carries the bad air into other places, what are such winds called?*

Pestilential winds.

Why are they called pestilential?

Because they make people, who breathe them, have a dreadful and dangerous disease, called pestilence.

Are there any other remarkable winds?

There are very *hot* winds blowing from the deserts of Arabia and Africa.

By what names are these hot winds called?

Simoom or Samiel, and Sirocco ; they have different names in different countries.

What name is given to the hot south wind in Egypt?

It is called Khamseen, or *fifty*-days' wind.

Why?

Because it continues fifty days.

When winds blow only at certain seasons or PERIODS *of the year, what are they called?*

They are called *periodical* winds.

What winds prevail in Egypt after the Khamseen is over?

The rest of the year the winds are northerly.

What sea is north of Egypt?

The Mediterranean sea.

When the vapor rises from this sea, where do these winds carry it?

Across Egypt to Abyssinia.

What becomes of the vapor, when it reaches that country?

The cool air changes it to rain, which falls in torrents to the earth.

Where does the water then go?

Some of it runs into the river Nile, and makes the river overflow its banks.

What good does this river do?

It passes through Egypt, where it never rains; and, when it overflows its banks, the whole country is watered by it.

How many times in a year does this river rise in this manner?

Once only.

What is this overflowing of the river called?

Inundation.

What would happen, if there were no such inundations.

The land of Egypt would be like a desert, and nothing could grow there.

Why would it be so dry and barren?

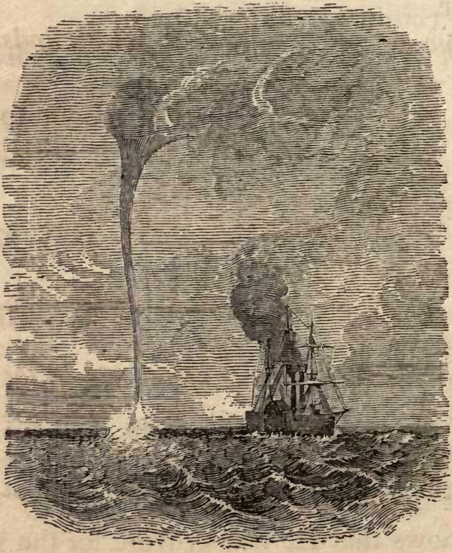
Because they have no rain, and all their water comes from this river.

How does this show the KINDNESS *of God?*

It shows that He will provide for the wants of man, in all countries where men live.

How does it show His POWER?

We see, from this, that He is able to bring water where it is needed, even when it does not fall from the clouds. "He causeth the wind to blow, and the waters flow."



What is a WHIRLWIND?

A wind that whirls very rapidly, and carries up into the air whatever is light enough to be lifted from the ground.

When it passes over the sea, what happens?

It raises the water, and forms the WATER-SPOUT.

How do we know that whirlwinds cause water-spouts?

A water-spout has been known to move from sea to land, and when it reached the land it became a whirlwind.

When a whirlwind passes over a sandy desert, what happens?

It raises the sand, and causes the *Sand-pillar* that travelers speak of.

Are whirlwinds ever mentioned in the Bible?

The prophet Nahum says, "The Lord hath his way in the whirlwind, and in the storm, and the clouds are the dust of his feet."

Lesson Sixteenth.

WHY *does smoke rise from the fire and go up through the chimney?*

Because the air in the fire-place, when heated, rises up and carries the smoke, which is also light, with it.

When the smoke goes out of the chimney, why does it not fall to the ground?

Because the warm air, which brought the smoke from the chimney, continues to rise and carry up the smoke with it.

What is this like?

It is somewhat like oil upon water.

Why does not the oil sink below the water?

Because the water is heavier than the oil.

If you should put the oil in the basin first, and then pour water upon it, would the oil remain at the bottom?

It would not; but would rise through the water, and lie upon the top of it.

Why would it?

Because the water is so much heavier, that it sinks down, and crowds the oil upward.

Why will not the smoke spread around the chimney, instead of rising higher?

Because the air above it is heavier, and crowds the light air, which is filled with smoke, upward, as the water did the oil.

How high will the smoke ascend?

Till the warm and light air that carries it comes to other air that is no heavier than itself.

How long will it remain there?

Till the air that carries it becomes as cool as the air around it; and then the smoke will slowly fall to the ground.

What makes soap-water bubbles rise in the air?

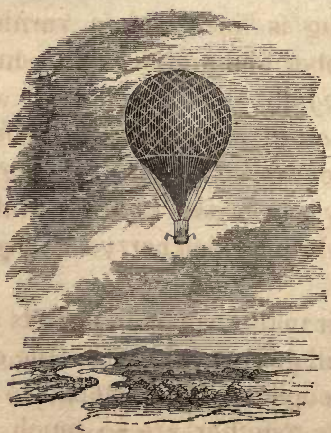
The light air that is in them.

If you could fill a thin bag with very light air, and throw it into the air, as you do soap-bubbles, what would it do?

The bag would rise.

How high would it rise?

Till it came to air of its own weight.



If you should fasten a bit of wood to it, would the bag carry up the wood with it?

It would, if the wood did not make the bag as heavy or heavier than the air around it.

How are balloons made?

A light bag of thin silk, somewhat like a very large bubble, is filled with a kind of air lighter than the common air.

How is this air kept from coming out of the bag?

The bag is lined with a varnish, made of India rubber and spirits of turpentine, so that it is *air tight.*

How can a person go up in such balloons?

A little *car* is fastened to the bag, which can carry one or two persons in it

How can a balloon carry a loaded car up into the air?

The air in the bag or balloon is so very light that it will go up; and, when the car, with one or two people in it, is fastened to the balloon, the whole together are so much lighter than

the air around them, that they can no more stay down to the earth than the hot air from the chimney can.

Do accidents ever happen to those who ascend in balloons?

Very often.

How?

When the balloon comes down, it sometimes falls into the sea, and the people in it are injured or drowned; and sometimes it strikes a tree suddenly, or is dragged violently along the ground, and the persons in it get hurt.

How can a balloon descend?

By letting out some of the light air from the bag.

How will this make the bag descend?

There will be less light air in the bag, to keep up the car; and so the balloon will be heavy, and descend.

What is a parachute?

It looks like a very large umbrella, open.

Of what use is a parachute?

If a balloon-bag bursts, or a car upsets, and the man in it has a parachute, he can hold upon the handle of it, and keep himself from falling quickly to the ground or sea.

How will the parachute hold him up?

While it is spread out, the air that it covers will support it so much that it comes down gently.

How can you make a little parachute?

By fastening strings to the four corners of a sheet of paper, then bring the four strings together in the middle, and fasten a light piece of wood to them.

Then what must you do?

Carry it to a high place, and let it fall.

How will it fall?

Very slowly indeed.

If you should have an open umbrella in your hand while falling or jumping from a high place, would you fall heavily to the ground?

I should not.

Why?

The air beneath the umbrella would support it, and so keep me from falling heavily.

How do birds keep from falling, when they are up in the sky?

They spread out their wings, and the air supports them.

Is this the only reason why the air supports them?

No; their bodies contain a great deal of air.

How can they remain in the same place in the air, without descending at all?

They strike the air beneath them with their wings a very little, and then the air *reacts* or *strikes back again* a very little, and as long as they do this they keep their places.

How do they rise in the air?

They strike harder against the air, and the air reacts just as much, and sends them up higher.

How do they descend?

By partly shutting their wings, and letting themselves descend by their own weight.

How do they know exactly what to do when they wish to rise, or descend, or stand still?

God, who made them, has taught them, and they never make a mistake, or forget how to do it.

Lesson Seventeenth.

How *are fishes able to keep themselves from sinking in water?*

They have fins, that spread out like the wings of a bird, and the water under them supports them, as the air supports the wings of a bird.

But you said that the body of a bird had a great deal of air in it, is it so with fish?

Fishes have bladders of air in their bodies, that make them lighter.

How can they sink down into the water, when they wish?

God has given them the power of letting out the air from the bladder.

How can they rise again?

God has given them the power of filling these bladders with air again, whenever they choose.

How do the fins of fishes differ from the wings of birds?

Their fins are not so large for them as the wings of birds are for them.

Why are they not made as large?

Because water is heavier than air, and supports fish better; so that fishes need no larger fins than God has given them.

How do people imitate fishes, when they wish to go into the water?

They take bladders, filled with air, and fasten them around their bodies, under their arms, and the air keeps them from sinking.

Do they ever use any other light body instead of blown bladders?

Cork is so light that it will not sink in water, and people use it in the same way as they do bladders.

What are SWIMMING-GIRDLES, AIR-JACKETS, *and* LIFE-PRESERVING BELTS?

They are India rubber bags, filled with air, and tied around the body, instead of cork or bladders.

What is the danger of using these bags?

If they should slip down to the hips, the heaviest part of the body would be above them, and the body would instantly turn, so that the head would be down and the feet up, and the person would soon drown.

What are life-boats?

Boats that contain tight cells along their sides, full of air.

Why are they called life-boats?

Because they take people from a sinking ship, and thus save them from a watery grave.

If you should fall into the water, what must you do first, to keep from drowning?

I must turn upon my back, and stretch my body out as straight as I can.

What must you do with your hands?

I must extend them under the water, with my hands open.

How must you place your feet?

I must keep them as near the top of the water as possible.

How must you place your head?

I must let it drop back, so as to have the top of it nearly covered.

Then what parts of your body will be above the water?

Only the face and a part of the chest.

What must you do then?

I must try to breathe, so as to take more air into my body.

When you throw out the air as you breathe, will not your body sink?

It will, a little, for an instant.

What effort may you make to keep from sinking?

If I can float so, I must not make any effort, except to keep my face out, so that I can breathe.

If you find your feet sinking, what must you do?

I must draw them up, and throw them out with a jerk.

What might happen if you did not try to keep your feet near the top of the water?

They might sink, so as to make my body stand in the water, and that would bring my mouth under it, and I should drown.

What must you be careful NOT *to do?*

Not to scream or struggle.

When may you call for help?

When I am a little over my fright.

Who are the least likely to sink, fleshy people, or those who are not fleshy?

Those who are fleshy.

Why?

Because the fat part of their bodies is so much lighter than water.

What amusing account can you give of Marco Paulo?

Marco Paulo lived in the city of Naples, many years ago. His bones were very small, and he was very fat. His body, also, would contain a great quantity of air. These things made him so light, that he would swim on the sea like a duck. When he stood up in deep water, the water would not rise higher than his stomach. It is said that, when two men dived into the sea to drag him down with them, the moment they let him go, his body instantly rose to the surface.

How can heavy bodies, like blocks of mar-

ble, be raised, when they have fallen into a harbor or river?

By fastening casks of air to them with ropes, when the water is low.

Why should the water be low?

Because the distance between the marble at the bottom, and the casks at the top of the water, would then be the shortest.

How could it be raised then?

When the water rises, it will bear up the casks with it, and they will carry up the marble, so that it can be taken into a boat.

Why would not the boat sink, after the heavy stone was placed in it?

One reason is, because the wood of boats is so light, and they spread out over a large space on the water.

Lesson Eighteenth.

IF *you should take a small glass tube, open at both ends, and put one end into water, what change would you see in the tube?*

I should see the water rise up into the tube.

What makes it rise?

The sides of the tube draw up the water in it.

What kind of attraction is this called?

Capillary attraction.

What is the meaning of CAPILLARY?

Hair-like.

Why is this attraction called capillary attraction?

Because the bore or hole through the tube is about the size of a hair.

In what tubes will water rise highest?

In those that have the smallest bore or hole through them.

If you take two pieces of flat glass, and put the two lower edges together, and leave the upper ones a little apart, and put the lower edges in water, what will happen?

The water will rise up between them.

What attracts the water?

The inner sides of the glass.

What kind of attraction is this?

Capillary attraction.

If you dip one end of a piece of sponge into water, why will the water rise above that part that was dipped in?

Capillary attraction makes it rise.

What are the capillary tubes of sponge?

The little holes that we see in it. Sponge is full of large and small capillary tubes.

What makes sponge so useful?

It will hold a quantity of water, and will drink up water that is spilled.

When such a substance as sponge drinks up a liquid, what do we say it does?

We say it *absorbs* the liquid.

Then what does sponge do to water, when put into it?

It absorbs the water.

Why will cotton and linen cloth absorb water?

Because the cotton and linen threads, of which cloth is made, are full of pores, or very fine capillary tubes, which attract the water.

If you take a bowl of water, and lay one end of a towel in it, what will happen?

After some time, the towel will be perfectly wet, and the bowl will be empty.

Where will the water be that was in the bowl?

It will all have run out, through the towel.

How can it go from the bowl to the towel?

The tubes in the linen draw the water out of the bowl.

Of what use are wicks in lamps?

They are a great number of capillary tubes, which draw up the oil from the lamp.

Why must not the wick be smaller than the lamp tube?

Because there would not then be tubes enough to bring up the oil.

Why must not the wick be so large as to be crowded tight in the tube?

If the wick was crowded very tightly, the capillary tubes in it would be closed, so that the oil could not rise through them.

What happens when you dip one end of a lump of sugar into water or tea?

The liquid will rise and fill the whole lump.

What makes it rise?

The capillary tubes in the sugar.

How are large rocks sometimes split, in Germany?

Holes are bored in a straight line, at certain distances from each other, and wooden wedges driven into them.

What is done after this?

Water is poured upon these wedges, and the pores or capillary tubes in them fill with water.

What follows?

The wedges begin to swell, and as they pour water upon them, they swell larger and larger, till they burst the rock. It is in this way that *grindstones* are broken off.

Is capillary attraction useful in any other ways than those you have mentioned?

It causes the moisture, that is low down in the ground, to rise up through the loose earth, to the roots of plants and trees.

Of what other use is it to them?

It causes the sap to ascend in trees, and to form beautiful leaves, and flowers, and fruit.

Of what use is capillary attraction to our bodies?

It assists in the circulation of the blood in our bodies.

When sugar, or salt, is dissolved in a liquid, what becomes of it?

It is divided into such very small particles that we can not see them.

How do you know that the sugar is in the water, if you can not see it?

Because the water is sweet after the sugar is put in, and it was not sweet before.

Does the water rise higher in the tumbler after the sugar is dissolved than it did before?

It does not.

What does this prove?

That there are exceedingly small spaces between the particles of water; and the particles of sugar fill up these spaces, so that the water does not rise to make room for the sugar.

What will happen when these spaces are full, if you put in more sugar?

The sugar will sink, and the water will rise in the tumbler.

When water has dissolved as much sugar as it can, what do we say of it?

We say the water is *saturated* with sugar.

If you should fill a tumbler full of marbles,

could you pour sand in it without taking out the marbles?

I could.

Where would the sand go?

Into the spaces between the marbles.

What is supposed to be the shape of the particles of water?

Round.

Then, when you put sugar into water, what is it like?

It is like pouring sand into a tumbler full of marbles.

How large are the particles of water?

Very small indeed.

When chalk powder is put into water, will it dissolve?

It will not, but will only mix with it.

How do you know it is not dissolved?

I can see it in the water, and the water, instead of looking clear, is thick and white.

What is the difference between MIXING *a solid in water and* DISSOLVING *it?*

When a solid is dissolved it can not be seen, neither does the water rise in the tumbler.

How is it when mixed?

It colors the water like itself, and makes the water rise in the tumbler.

What are those bodies called which can be dissolved?

Soluble bodies, or bodies that can be dissolved.

What are those called which can not be dissolved?

Insoluble bodies.

Lesson Nineteenth.

WHAT *instrument shows the effect of water pressure?*

A hydrostatic bellows.

If you wish to make a hydrostatic bellows, what would be the first thing you would do?

I should get two round pieces of board, and fasten them together with leather, so that they would rise and fall together like common bellows.

What would you do next?

I would take a long tube, and fasten it to one side of the bellows, so that the lower end of the tube would open into the bellows.

How would you make the tube stand erect, after it was fixed to the bellows?

By bending it up from the bottom.

What shape must the top of the tube be?

Like a tunnel.

If a man should stand upon the bellows and pour water into the tube, what would follow?

The upper side of the bellows would begin to rise, to make room for the water, and raise the man standing on it, higher and higher, till the bellows was full.

What supports the man?

The water in the bellows.

How can water run into the bellows, while a heavy man is standing upon it?

The water in the tube presses the water

at the bottom of it into the bellows, because its own downward pressure is greater than that of the man.

Then what kind of pressure does the downward pressure of water make?

Sidewise, or lateral pressure.

What is the meaning of LATERAL?

Sidewise.

Then when the downward pressure of the water in the tube presses that in the bottom sidewise into the bellows, what other pressure follows?

Upward pressure.

What causes the upward pressure of the water?

The lateral, or sidewise pressure.

How does it?

When there is no more room in the bellows for the water to move sidewise, it must press upward, if the water is continually running in, because it can go no other way.

How could you let the water out of your bellows?

By making a hole at the bottom of the tube.

How can you show the pressure of AIR *with the same instrument or bellows?*

Two men may stand on it, and one of them may blow hard into the tube, instead of pouring in water, and they will both be lifted up.

How can they keep the air in the tube and bellows from coming out?

By putting the finger tightly down upon the top of the tube.

If you fill a vial almost full of water and cork it, and then turn it up and down, what will you see moving up and down along the side of the vial?

A bubble of air.

If you lay it on an inclined plane, where will the bubble be?

Near the upper end of the vial.

Where will it be if you lay it on a level table?

Exactly in the middle of the vial.

How can you tell whether a table is level, or inclined?

By laying the vial on it, and looking at the bubble, to see if it is in the middle or near one end.

What useful instrument is made somewhat in this way?

A spirit-level.

What is a spirit-level?

It is a glass tube, nearly full of colored spirit, and is fitted into a brass case, in such a way that the bubble of air can be seen.

If you wish to find whether the floor is level or inclined, how must you use this instrument?

I must place it on the floor, and see whether the bubble of air is in the middle of the tube.

For what purpose is the spirit-level often used?

It is used in making roads and canals.

What are canals?

They are large, long ditches, filled with water, that go from one town to another.

Why are canals made?

Because there are no rivers in just the places where men want them, and so they make rivers for themselves, for boats to sail upon.

Where do they get the water to fill their canals?

From the rivers near them.

What is done when a canal must go across a river?

They make tight bridges, which carry the water in the canal safely over the river.

What are such bridges called?

Aqueduct bridges.

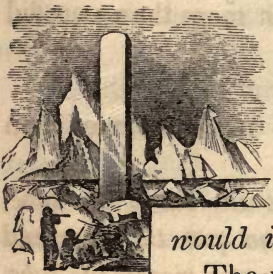
What is the meaning of AQUEDUCT?

Aqua means *water*, and *duct* means *leader.*

Then what do you mean by AQUEDUCT?

A water-leader.

Lesson Twentieth.



IF I should take a glass tube, open at both ends, and put it into a bowl of water, and then press down all the water around the tube, what would it do?

The water would rise up into the tube.

What would make it rise into the tube?

Your hands would press down the water around the tube, and the water could not help rising in the tube

What is mercury?

It is a liquid metal, that looks like melted silver.

What is mercury sometimes called?

Quicksilver, or liquid silver.

If I should put quicksilver or mercury into the bowl, instead of the water, and then press it down, would it rise in the tube?

It would; but not as high as the water rose, unless you pressed upon it more than you did upon the water.

Why would it not?

Because mercury is so much heavier than water.

If I could take all the air out of the tube, and stop the upper end, and put the other end into the water, would the water rise in the tube, if I did not touch it?

It would.

What would make it rise?

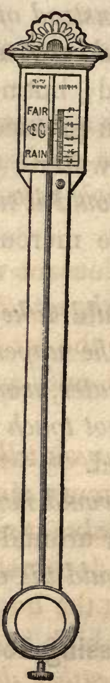
The air around the tube.

How could the air make the water rise in the tube?

By pressing down upon the water in the bowl.

What does this prove?

It proves that the air has weight.



What is the name of the instrument, made of such a tube and bowl of mercury?

Barometer.

What is the meaning of the word BAROMETER?

It means a measurer of weight.

When the air is so heavy as to press up the mercury high into the tube, what weather do we have?

Clear, pleasant weather.

Why is the weather pleasant then?

Because the air is heavy enough to hold up the clouds, and prevent them from falling down.

How can you tell when the air grows lighter?

The mercury sinks in the tube.

What makes it sink?

The air does not press so heavily upon the mercury in the bowl, and so the mercury can not rise as high in the tube.

What weather do we have when the mercury sinks in the tube?

Stormy weather.

Why do we have stormy weather?

Because the air is not heavy enough to hold up the clouds, and so they fall down in rain.

Then what good does a barometer do us?

It shows us what weather to expect.

Who always need barometers?

Captains of ships, at sea.

Why do they need them?

Because a sudden storm would destroy a ship sooner than it would a house.

How would a barometer prevent a ship from being destroyed?

The captain could see the mercury sinking in the tube, and would immediately prepare the ship for the storm, and thus save it.

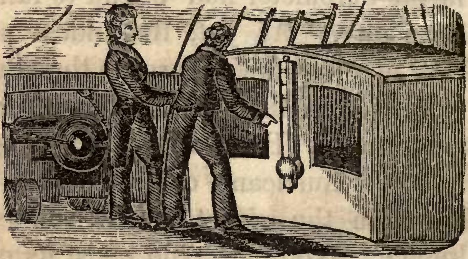
Can you relate a story of a captain's saving his ship, because he had a barometer?

Dr. Arnot gives the account. He was in the ship at the time. He says they were in the southern hemisphere. The sun had just

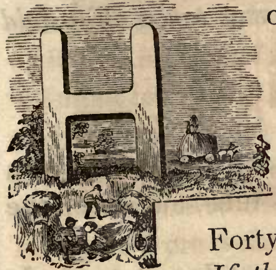
mildly set, closing a beautiful afternoon. The evening amusements were going on as usual, when suddenly the captain's orders came to prepare with all haste for a storm. The mercury in the barometer had begun to fall with awful rapidity. As yet, the oldest sailors could see nothing like a storm in the sky, and were surprised at the greatness and hurry of the preparations. But before every thing was quite ready, a hurricane came on them, more dreadful than the oldest of the sailors had ever known. Nothing could resist its power. The sails were torn to tatters, the masts injured, and, at one time, the whole rigging was near being destroyed. So loudly, for a few hours, did the hurricane roar above, the waves around, and the dreadful thunder peal, that no human voice could be heard; even the speaking-trumpet sounded in vain.

On that awful night, if it had not been for the little tube of mercury which gave the warning, neither the strength of the noble

ship, nor the skill and activity of her commander, could have saved one man to tell the tale.



Lesson Twenty-First.



How *high above the earth does the air extend?*

Forty-five miles.

Then how many miles of air press down upon the mercury in the bowl?

Forty-five miles of air.

If the tube was as large as a pump, and the bowl as large as a cistern, would water rise in the tube?

It would.

What would make it rise?

The weight of the air pressing upon the water around it.

What is necessary to the making of a pump?

A large tube, with the upper end closed.

If there was AIR *in the pump, would the water rise in it?*

It would not.

Why would it not?

Because the air and water could not be in the same place at the same time.

If the top of the pump was taken off, would the water rise in it then?

It would not.

Why would it not?

Because the air above the tube could then press down through the tube, and keep the water from rising.

How could the air be taken out of the pump.

By making a stopper just as large as the hole through the pump, that can slide up and down in it

What is the stopper in a pump called?

It is called the *piston*. It has a hole through it.

What is there on the top of this stopper or piston?

Just over the hole in the piston, there is a little leather cover, fastened so as to open and shut like a little door on a hinge.

What is this COVER *called?*

It is called a *valve*, or little door.

Where is there also another valve?

In the lower part of the pump.

You said the air could be taken out of the pump by such a piston as you have described; how could this be done?

When I press the piston down toward the water, the air underneath lifts up the cover or valve in it, and escapes through the hole.

What will then be below the piston?

Nothing but water.

If you now raise the piston, what will the water do?

It will open the lower valve and rise as fast as the piston rises.

What will make the water rise?

The air pressing upon the water in the cistern, outside of the pump.

When the piston is pressed down the second time, what will take place?

As it is pressed down, the water under it closes the lower valve, and forces up the little valve of the piston, and when it is open, the piston can sink down through the water.

What will take place when the piston is drawn up again?

The water above the piston will press upon the little valve and close it, so that the water can not pass back through the piston again.

What becomes of the water above the piston then?

As the piston rises, it lifts up this water, and throws it from the pump.

How could you raise as much water as you wish?

By moving the piston down and up several times.

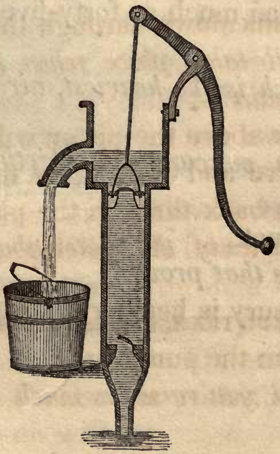
How could you press down the piston?

By having a long pole fastened to it, with a handle at the top of it.

What is the long pole called?

The pump-handle.

Here is a picture of a pump.



How high will water rise in a pump, where there is no air?

Thirty-four feet.

Why will it rise no higher?

Because the air does not press heavily enough upon the water in the cistern, to raise the water any higher in the pump.

What does this prove?

It proves that thirty-four feet of water weighs just as much as forty-five miles of air does.

Then which is the heaviest, air or water?

Water.

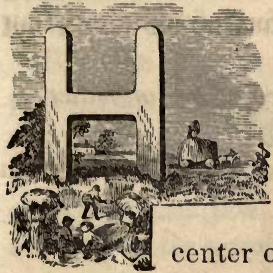
Would the mercury rise thirty-four feet in a tube?

It would not.

What does that prove?

That mercury is heavier than water.

Lesson Twenty-Second.



How *do boys make the play-things which they call* SUCKERS?

They take a round piece of wet leather, and fasten a string in the center of it.

How do they use it?

They press the leather very closely to the stone which they wish to lift, and then, when they lift up the leather with the string, the stone comes up with it.

What makes the stone rise too?

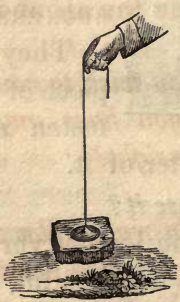
When the string pulls up the leather, it stretches the leather, because it is wet, so that nothing but its edges touch the stone.

Then what is between the leather and the stone?

Nothing, not even air.

How do you know there is no air under the leather?

Because the edges of the leather are fixed so tightly to the stone, that no air could get under it.



Then what keeps the stone and leather so tightly together?

The pressure of the air.

What does this prove?

That air has weight.

What if the edge should be lifted up on one side?

The air would get between the leather and the stone

Could you lift the stone with the sucker then?

I could not.

Why could you not?

Because the air under the sucker would press it up, while the air above was pressing down.

Then when you wish to raise any thing with a sucker, may you have any air between the sucker and the weight?

I must not.

How can a fly walk upon a window-glass?

Its feet are much like suckers, and are kept upon the glass by the pressure of the air.

How can they take them up from the glass, so as to walk as fast as they do?

God has given them the power of letting the air under their feet very quickly, whenever they wish to step.

Are there any other animals that walk over smooth surfaces by means of such feet?

The lizzard, that lives in the island of Java, walks up a smooth wall in the same way, to catch flies; and the large walrus walks upon ice easily, because his hind feet are shaped like a sucker.

Have any kinds of fishes this contrivance?

One kind of fish has a set of suckers upon its head, that enables it to fasten itself to rocks, or to any thing it chooses.

If you should cork an empty bottle, and let it down deep into the sea, what would happen to the bottle?

It would be crushed.

What would crush it?

The water pressing all around it would crush it in.

What does this prove?

It proves that the pressure of water is greater than the pressure of the air.

If you fill the bottle with water, and cork it,

and then let it down into the sea, will it be crushed?

It will not.

Why will it not?

Because the water in the bottle presses outward so strongly as to prevent the pressure of the water around the bottle crushing it.

If you should take a tight barrel, filled with water, and make a hole on the under side for the water to run out, would it flow?

It would not.

Why would it not?

Because there would be nothing to press it down.

How could you make the water run?

By making another hole in the upper side of the barrel.

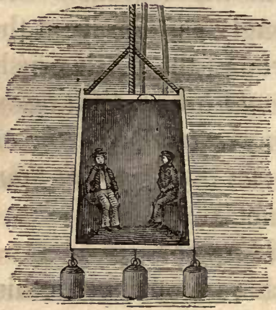
What good would that do?

It would make a place for the air above the barrel to press down upon the water in the barrel.

Then when you wish to have the fluid in the

barrel run out at one end, what must you always do?

I must take out the *bung* or stopper at the top, to let the air come into the barrel.



What contrivance have people for going safely to the bottom of the sea?

They can go in *Diving-Bells.*

What are they?

They are shaped like a bell, and are large enough for one or two persons to sit in them.

How is the water kept out of them?

They are let down into the water in such a way that the air in them can not escape; and thus the air prevents the water from rising into them.

How can you explain this?

If I put a tumbler into water, with the upper side down, I can not fill it, because the air in it will not allow the water to come up into it too.

How can the persons in the diving-bell breathe?

A long, flexible tube goes from the inside of the bell up through the water, and the air is passed down to the men through it.

What other contrivance has been made, for the same purpose?

Instead of a bell, a tight cover has been made for the head, which has an air-tube fixed to it. A man can fasten this cover upon his head, and put on a water-proof dress, and then go safely down to find pearls, or wrecks of ships, at the bottom of the sea.

Lesson Twenty-Third.

F *you throw a stone into the water, what will the water do?*

It will move in little waves, shaped like circles, and these circles will grow larger and larger.

When the steeple-clock strikes, what does it cause the air to do?

It makes the air around it move in circular waves, just as the water does when a stone is thrown into it.

When one of the circles reaches your ear, what do you say?

I say that I hear the clock striking.

Then what is sound?

Sound is the effect of air coming against the ear.

What are these circular motions, or waves of the air, called?

They are called *vibrations* of the air

What is necessary then to make a sound?

Something that will vibrate.

How is it known that sound is conveyed by means of air?

A bell has been rung in a glass vessel, when the air was taken out of it, and it made no sound.

If a cannon should be fired several miles off, would you hear it the moment it was fired?

I should not.

Why would you not?

Because it takes some time for the waves made by the cannon to reach my ears.

What brings the sound of the cannon to your ears?

The air.

Then what may we call the air?

A *conductor* of sound.

Why do we hear a bell ring more distinctly, when the wind blows toward us from the bell?

Because it brings more waves of air to our ears, than would reach us, if the wind did not blow that way.

When the wind blows in a different direction, how does the bell sound?

Very faint, and sometimes we can not hear it at all.

Why is the sound so faint?

Because the wind blows almost all the waves of air away from our ears.

If you strike two stones together in water, can you hear the sound as plainly as you can in the air?

I can, if my head is under the water.

What does this prove?

It proves that water is a good conductor of sound.

Which is the best conductor of sound, water or air?

Water.

How can this be proved?

If a bell should be rung in water by one person, and another person at a distance should put his head under the water, it would sound much louder than if the bell and the person were out of the water.

If you lay your ear upon one end of the table, and I scratch the other end of the table with a pin, will you hear it?

Yes; and it will sound very loud.

What does this prove?

It proves that wood is a good conductor of sound.

Why do animals seem to know an earthquake is going to take place sooner than men do?

Their heads are so near the ground that they hear the rumbling sound first.

What does this prove?

It proves that the earth is a good conductor of sound.

Can you repeat a story that shows what good

it has done to know that the earth is a good conductor of sound?

Many years ago, there was a war in Greece. The Greeks fought against the Turks, because the Turks had got their lands away from them, and treated them very cruelly. In one of the Greek cities, there was a strong tower. The name of the city was Missolonghi. A great many Greeks had fled to this tower, to get away from the Turks. The Turks came, and tried to destroy the tower. It had a great quantity of powder in the cellar, for the Greek soldiers to use. After trying a good while to destroy it, the Turks went away, as if they were not going to try any more. They began to dig a hole at some distance from the tower. The Greeks did not know what it was for; but soon one Greek began to think that the Turks were digging a hole under ground, to reach the cellar of the tower. He thought that they would lay tow all along, (from the powder in the cellar to

the beginning of the hole,) and then set fire to the tow. This would burn till the fire got to the powder in the cellar, and then that would take fire and blow up the tower, and all the people in it.

What did the Greek do?

He piled up some stones in the middle of the cellar, or magazine, as a cellar of powder is called, and put four smaller stones very loosely upon the top. Then he watched those four stones till he saw them shake. As soon as they began to shake, he put his ear down to the earth, and could hear which way the sound came from. As soon as he found out which way the sound came from, he began to dig down, and soon came to the tow that was laid there, all ready to be set on fire. This he destroyed. When the Turks had set the further end on fire, they waited at a distance to see the tower blow up. When they found that it did not blow up, they began to dig somewhere else.

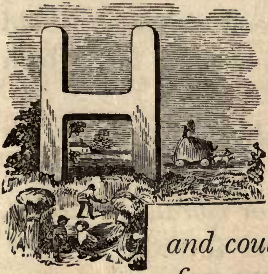
What did the Greek do then?

He kept watching the stones, and soon saw them shake again. Then he put his ear down and heard the noise, and dug again till he came to another train of tow, and destroyed that.

Did the Turks try again?

They did, several times; but at last they began to think that the Greeks knew what they were doing, and so they gave over trying to blow up the tower.

Lesson Twenty-Fourth.



How *fast does sound pass through the air?*

One mile in about five seconds of time.

Then, if you should see the flash of a cannon, and could count thirty seconds before you hear the first sound, how far off should you say the cannon was?

It would be six miles off.

How could you tell?

If it goes one mile in five seconds, it would go six miles in thirty seconds, because there are six times five in thirty.

If it should lighten, and you should not hear it thunder till you had counted fifteen seconds,

how far off should you say the thunder-cloud was?

Three miles off.

How would you find out that?

There are three times five seconds in fifteen seconds, and if five seconds would bring the sound one mile, fifteen seconds would bring the sound three times as far, which would make three miles.

If you speak very loud, what will the air around you do?

It will begin to move or *vibrate* in circles, that will spread further and further.

If these circles spread till they strike against a high rock, what will happen to them?

The rock will *reflect* or send them back, just as it would a ball, if you threw one against it

If the circles made by the reflection of the rock should come back to the ear, what would you say?

I should say I heard the *echo* of my voice.

Then what is an ECHO?

An echo is sound sent back again.

What besides rocks will echo?

Hills, buildings, and walls of rooms, if they are near enough and not too near.

How near must they be, in order to make an echo, when you speak very loud?

So near that the circles made by my voice can reach them, and that they can send the circles back to me.

If the rock should also send its circles to another rock, that would send them back to your ear, what would you hear?

I should hear *two* echoes.

How would it be, if several rocks or surfaces sent back the sound at different instants?

I should hear several echoes.

Are there any places where several echoes can be heard?

There are many in the world.

Can you mention one in the United States?

At Lake George there is a place where a

person can stand, and call out very loudly, and he will hear several echoes.

What curious echo is there in England?

At Woodstock, there is an echo that will repeat seventeen syllables; and, on the north side of the church at Sussex the echo will repeat twenty-one syllables.

What one still more wonderful can you mention?

In Italy, near the city of Milan, there are two walls of a building that face each other, and a person, standing at a window between them, can hear the echo repeat one word more than *forty* times.

How is it when a pistol is fired there?

The echo repeats the sound *sixty* times.

What can you say of the Whispering Gallery of St. Paul's Church, in London?

If a person whispers very softly close to the wall on one side of the gallery, it will be echoed so that, if another person puts his ear close to the wall on the other side of

the gallery, he can hear every word distinctly.

What is an Eolian Harp?

A musical instrument made with strings.

Can you describe it?

Strings or wires are stretched very tightly from one fastening to another, and placed where the wind can blow directly upon them.

What does the wind do to the strings?

It makes them strike against the air, and, when the circles made by them reach your ears, you hear very sweet sounds.

What very large one was made in Milan, many years ago?

Gattoni stretched seven strong iron wires from the top of a tower fifty feet high to the house of Signor Mascati.

What was it called?

The *Giant's Harp.*

Why was it called the Giant's Harp?

Because, when the wind blew, it sent forth

such lengthened peals of music: now it was a loud chorus, and then it died away in soft murmurings. In a storm it was heard several miles.

Lesson Twenty-Fifth.

WHEN *children carry fruit along the streets in cities, to sell, why do they turn toward the houses they pass, and put their hand up to one side of their mouths, when they scream out—"Strawberries?"*

So as to make the sound of their voices go into the windows, instead of spreading out and being lost in the noise of the streets.

When a boy is calling to another, who is at a distance, what does he often do?

He puts both hands around his mouth, like a tube, and then calls.

Why does he put his hands around his mouth?

They keep the sound from spreading out, and thus make it go straighter to the other boy's ear.

If the other boy hears the sound, and turns around to know what is wanted, what will he do?

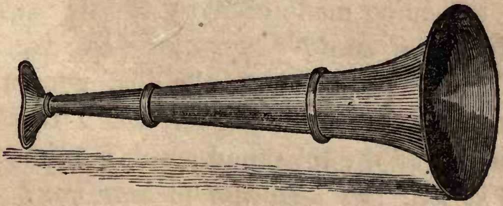
He will probably put one hand to his ear, to listen.

Why will he do so?

So to catch more of the sound of his friend's voice.

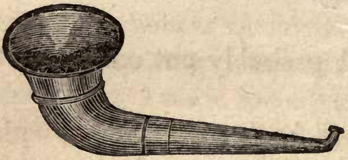
What do firemen and sea-captains use, instead of their hands, to make their orders heard in a great noise?

They use *speaking-trumpets.*



What contrivance have people for hearing, instead of putting the hand to the ear?

They have *ear-trumpets*, or tubes.



How can deaf people hear the conversation of their friends?

They have a long, *flexible* tube of India-rubber, with a small ivory opening at one end, to go into the ear, and at the other end is a larger opening made of ivory.

How is it used?

If I wish to speak to the deaf person, he puts the small end to his ear, and I take the other end of the tube, and speak *into* it.

Why will this help him to hear you?

The sound goes directly from my lips, through the tube, into his ear.

How is it when you have no tube?

The sound goes every way when it leaves my mouth, and so but little could go into his ear.

What contrivance is made in houses, by which people in the upper part can easily talk with those in the rooms below?

Tubes are put into the walls, with openings from them into the rooms, upstairs and below.

How are they used?

If a person in the upper room speaks into the tube opening there, the other in the room below hears, and goes to the opening in *his* own room, and puts his ear to it to listen, and then speaks back through the tube.

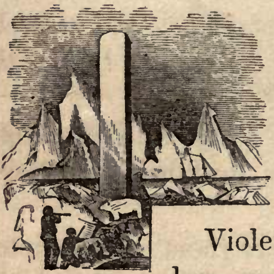
Must they talk very loud?

They need only speak as if they were in the same room.

Why?

Because the sound is kept in the tube till it gets to the othe opening.

Lesson Twenty-Sixth.



INTO *how many colors may light be separated?*

Light may be separated into seven colors.

What are the names of these colors?

Violet, indigo, blue, green, yellow, orange, red.

When light shines upon a sheet of paper, how can you see the paper?

By the light which the paper *reflects* or *throws back* to my eyes.

Would the paper reflect ALL *the light that shines upon it?*

If it was white paper, it would.

How do you know that WHITE *paper reflects* ALL *the light that falls upon it?*

Because it takes all the seven colors to make white light, and the paper looks white, which it could not do if it did not reflect all the seven colors.

How do you know that it takes all the seven colors to make white?

Because, if you separate a ray of white light by a prism, it will be changed into just seven colors, and no more; and if you bring all these seven colors together again, they will form a ray of white light.

Do all bodies reflect all these colors?

They do not; some reflect one color, and some another.

What becomes of those colors which the body does not reflect?

That body *absorbs* them.

What do you mean by a body's ABSORBING *colors?*

It seems to take them into itself, so that we can not see them.

If a body should absorb all the col-

ors, and reflect none, what color would it have?

It would not have any color.

Then what should we call it?

We should call it a *black* body.

Then is black a real COLOR?

It is not.

Then, when we say a body is black, what do we mean?

We mean that the body has *no* color.

And, when we say a body is WHITE, *what do we mean?*

That it has *all* the seven colors.

If it absorbs all the colors but the red, and reflects the RED, *of what color will the body be?*

It will be a *red* body.

What color shall we call it, if it reflects the green, and absorbs all the rest?

We shall call it a *green* body.

How can you tell which color a body reflects, and which it absorbs?

It will be of the color it reflects, and

we shall know it absorbs all the colors but that.

Then how do we see any object?

By the color it reflects to our eye.

What is the reflection of light like?

Like the reflection of sound.

Can you explain it?

The sun shines upon a green leaf, and the leaf reflects the green color to my eyes, just as a person stands out of my sight and calls, and the rock on which the sound of his voice falls reflects it to my ear.

Why do not all bodies reflect THE SAME *color and absorb the others?*

Because the particles of bodies are put together differently; so that one body can reflect one color, another all of them, and another none.

Which would reflect ALL?

A *white* body.

Which would reflect NONE?

A *black* body.

If you should go into a perfectly dark room, and let in a ray of light, through a small hole in the shutter of the window, and put a PRISM *over this hole, what would the prism do to the light that came through it?*

It would separate it into the seven colors.

Would all these colors be mixed together?

They would not.

How would they be?

They would lie one beneath the other, very distinctly, like the colors in the rainbow.

Then do they all go through the prism in a straight line together?

They do not; they are broken, and turned out of the straight line.

When a ray of light is broken, and turned out of a straight line, in passing through a body, what do we say of it?

We say the light is *refracted.*

What is the meaning of REFRACT?

To *break.*

When is light REFRACTED?

When it is *broken.*

If you should put a piece of white paper into the BLUE *ray that has passed through your prism, of what color would the paper be?*

It would be *blue.*

Why would it be blue?

Because it could reflect only the blue color

Why would it not be white?

Because it must reflect the seven colors to make white, and there is but one for it to reflect when the blue alone falls upon it.

If you should put the paper into the yellow ray, of what color would it be?

It would be yellow.

What does this prove?

It proves that bodies are of the color which they reflect.

Then, if no light should fall on a body, would it have any color?

It would not.

Why would it not?

Because there would be no color for it to reflect.

When a body does not reflect any color, what do we call it?

A *black* body.

If a room is so dark that no light can enter it, of what color will the objects in the room be?

They will be of no color; because there is no color to be reflected.

Then what must we call them as long as they are in the dark?

We must call them black bodies.

Can we ever see them, when they are made black in this way?

We can not; because we can see nothing when it is *perfectly* dark.

Why can we see a tree upon tne top of a hill at a distance, plainer than we can see one on a plain, or in a valley, at the same distance?

Because the sky behind the tree on the hill is so much lighter than the tree, that we can see the shape of the tree very distinctly.

Why is not the tree in the valley as distinct as the one on the hill?

Because the green color of the grass behind the tree seems to mingle with the green of the tree, and we can not distinguish the one from the other.

Why can we see a WHITE *house at a distance, plainer than we can see a tree at the same distance?*

Because there is so great a difference between the white object and the dark ground around it.

If you wish to make a room very light, what should you do besides having many windows in it?

I would have the walls white, or papered with very light-colored paper.

Why would light paint and paper make a room lighter than dark paint and paper, if there were the same number of windows in it?

Because white walls throw all the light that falls upon them back into the room, and dark

walls absorb some of the light, and reflect only a part into the room.

Why do people, who have weak eyes, wear a shade over them in the day time when reading?

To keep the light that is reflected from the walls of the room from coming into their eyes.

Why do they wear a shade when reading by candle or gas light?

To prevent the rays of light that come from the candle or gas from entering their eyes.

Is HEAT *reflected in the same manner that light is?*

It is.

Then why is a white dress so cool in summer?

Because it reflects the heat of the sun.

Why is a black dress so warm?

Because it absorbs the heat.

How can you prove that white reflects heat, and black absorbs it?

If I place a piece of white and a piece of

black cloth upon snow, after sometime, I shall find the snow melted beneath the black, but not beneath the white cloth.

When the heat of the sun falls upon the side of a mountain, what becomes of a part of this heat?

It is reflected in various directions.

If a valley is surrounded by such mountains, will it be warm or cold?

It will be warm.

Are there any such valleys?

There are valleys in Switzerland, surrounded by such mountains, that receive so much reflected heat from every side, that they are always green, though they are in the midst of perpetual snow.

Lesson Twenty-Seventh.

WHAT *wonderful thing can be done by means of the light of the sun?*

Pictures of people can be made by it.

What are such pictures called?

When they are made upon little plates of *metal*, they are called *daguerreotypes.*

Why do they have that name?

Because Mr. Daguerre first found out how to make such pictures.

When they are made upon PAPER, *what are they called?*

Photographs.

Why are they called photographs?

Because *photos* means *light*, and *graph* means written or drawn.

Then what does photo-graph mean?

It means *drawn by light.*

But are not daguerreotypes drawn by light too?

They are; but the names are different, to show the difference of the pictures.

Can the pictures be drawn on glass?

They can; and then they are called *ambrotypes.*

Can the colors of the picture be made too by light?

A Mr. Hill has found out a way to make the colors on the pictures too, and his pictures are called *Hillotypes.*

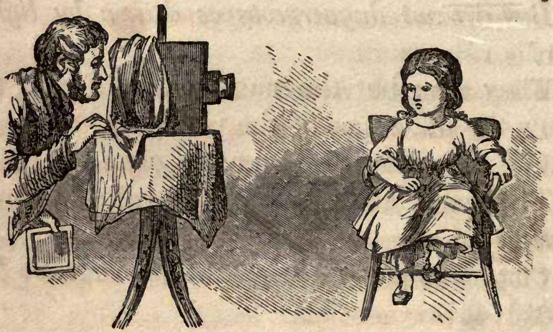
Why do they have that name?

To show that it was a Mr. Hill who found out the way to make them.

If you were going to have a picture of yourself taken, what would you do?

I should sit or stand before a small box

that had a glass in the side toward me, and I should look at that glass as I would into a looking-glass.



What is in the box, behind that glass?

The metal or paper on which the picture is to be made.

While you are looking at the glass what happens?

A picture of myself is made, just as if by looking into a looking-glass I should leave a picture of my face upon the looking-glass.

But is your picture made upon the GLASS *in the side of the box?*

No; it passes through it, and is made upon the metal behind it.

Is the picture as large as yourself?

It is very small.

What makes it small?

The glass I look at is so formed as to make things look a great deal smaller than they are, and this makes the picture small.

How long do you have to keep perfectly still and look into the glass?

Only a few seconds.

Can the picture be made upon ANY *piece of metal or paper?*

No; something is put upon it first to prepare it, to keep the picture from passing away.

What has to be done after the picture is taken out of the box?

When it is taken out, the artist, in some peculiar way, *fastens* the picture to the paper, before he puts it into its frame.

Do we know whether any better way to make such pictures could be found out?

We do not; because people are always trying to find out better ways of doing things.

When any better way is found, what is it called?

It is called an *improvement.*

Could our EYES *be made any better?*

They could not.

Why?

Because *God* made *them*—it is only what man makes that can be made better.

Lesson Twenty-Eighth.

LOOK *into my eye, and tell me what you see?*

I see a white ball, with a ring of some color on the middle of it, and in the ring a round black spot.

Look into that black spot, do you see any thing there?

I see a little picture of my own face, as if I were looking in a very small looking-glass.

Now, if I turn my eye toward a bright light, what will you see in it?

I see the colored ring seem to draw up around the black spot, like drawing up a bag

with a string, and the black spot looks much smaller.

If I now turn away from the light, what will you see?

The ring seems to spread out, and the black spot looks larger again.

Then do you see what the ring does to the black spot?

I do; it makes the spot larger or smaller, like opening and shutting a bag with a string.

Which part of your eye do you see with?

The black spot.

What is the name of the black spot?

It is called the *pupil* of the eye.

What is the name of the colored ring?

It is called the *iris.*

What is the color of the PUPIL?

It is always black.

What is the color of the ring, or iris?

It is sometimes blue, sometimes gray, and sometimes dark brown, or, as it is called, black.

Then, when we say any one has blue or black eyes, what do we mean?

We mean that the *iris* of the eye is blue or black.

What is the use of the iris?

When the light is very bright, the iris keeps too much of it from coming into the pupil.

Is it of use when there is very little light?

It is; for it opens the pupil very wide, so that light enough may come into the eye for us to see easily.

How can it?

God has given it the power of opening wide in the dark, to let in all the light it can, and then of almost shutting or drawing up, when the light is too great.

Why does it hurt our eyes to look at lightning at night, or at any sudden light?

Because the iris has not time to draw up so suddenly, and so too much light comes into the pupils.

What has God made to protect our eyes?

The eyelids.

How does he give the eyes rest?

By sending the darkness of night, to keep off all light from them.

Then is it well to sleep with a light in your room at night?

It is not; because our eyes need the rest that darkness brings, to keep them well and strong.

Is it well to have the bright sun shining in your room when you first open your eyes in the morning?

It is not; because the iris can not draw up around the pupil quick enough to keep too much light from coming into it.

Then how is the best way to have your bed placed in the room?

So that the windows shall be behind me when I wake in the morning.

Why can tigers, cats, and owls see in the dark?

Because God has given them power to make

the pupils of their eyes larger than ours, and thus more light can come into them than can come into ours at night.

Why do tigers and many other wild animals need to see better in the dark than we do?

Because they seek their food by night, while we sleep.

When you go from a light room into one almost dark, why can you not see objects at first as plainly as you can afterward?

Because it takes a little time for the iris of my eyes to open wide enough to let in what light there is in the dark room.

Lesson Twenty-Ninth.

WHAT *can you tell me about the use of glass for seeing objects?*

It is used for windows, for mirrors or looking-glasses, for spectacles, for microscopes, and for telescopes.

What kind of glass is made for windows?

Glass perfectly plain and even on both sides.

What for looking-glasses?

The same kind of glass, with one side covered with quicksilver.

What is the use of the quicksilver?

It *reflects* whatever is in front of the glass.

What kind of glass is used for spectacles?

For the eyes of old people, the glasses in spectacles must be made thicker in the middle than at the edges.

How must it be for short-sighted or near-sighted people?

Their glasses must be thickest at the edge, and thinnest in the center.

Of what use are the glasses in telescopes?

They seem to bring the moon and stars nearer to us, because they make them look so much larger, and show us many we never saw before.

What are those glasses that make objects look larger called?

They are called *magnifying-glasses.*

What does MAGNIFY *mean?*

Making large or great.

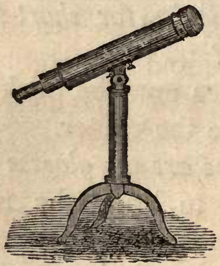
There are other glasses that make very small objects look immensely large, what are they called?

Microscopes.

What is the meaning of MICROSCOPE?

Micros means *little*, and *scopeo* means *I see.*

What does telescope mean?



Tele means *distant*, and *scopeo* means *I see.*

Tell me something about the MICROSCOPE?

If you were to look at the down of the butterfly's wing with a microscope, it would look like beautiful feathers.

How would a drop of rain-water look?

As if it were full of large and strange-looking animals or insects.

How would very small insects look?

Large and sometimes very beautiful.

What do we learn by using a microscope?

We learn that God has made these little creatures, and little flowers, even those that are too small to be seen without a microscope, just as perfect and as beautiful as those that are very large and splendid.

What kind of a glass do sea-captains use?

They use a *spy-glass.*

What is a spy-glass?

A glass that makes distant objects seem near.

Then what is its use?

The captain is able to see any distant ship, or land, before he is near enough to them to see them with his eye alone.

What other glass is the spy-glass like?

It is just like the telescope, only smaller.

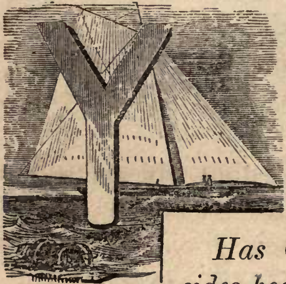
What is a PRISM*?*

A three-sided piece of glass.

For what is it used?

To separate the light that passes through it into its seven colors, like a rainbow.

Lesson Thirtieth.



You *have told about light and heat, can we see light?*

We can.

Can we see heat?

We can not.

Has God made any thing besides heat that we can not see?

Yes; he has made a wonderful *fluid* that can not be seen, and yet it seems to be every where.

What is the name of this wonderful fluid?

It is called *electricity*.

If it can not be seen, how do we know there is any such fluid?

We see what it *does*, just as we see what heat *does*.

What does electricity do?

It causes the lightning.

What is lightning?

It is caused by electricity passing from the cloud to the earth, or from one cloud to another

How many kinds of electricity are there?

Two; and these always attract each other.

What are they called?

Vitreous and *resinous;* they are also often called *positive* and *negative* electricities.

Why does electricity pass from one cloud to another, or to the ground?

Because they are in different states of electricity, and so they attract each other.

If the cloud is over a tall tree, or church-spire, what way does the electricity take to pass from the cloud to the ground?

It often goes down the tree or spire.

Then what do we say has happened to the tree?

We say it has been struck by lightning.

Then the tree would LEAD *or* CONDUCT *the lightning, would it not?*

It would; and we should call it the *conductor* of the lightning.

Is it safe to stand under a tree in a thunderstorm?

It is not.

Why are lightning-rods fixed to houses?

To keep the lightning from striking the house.

How can they keep off lightning?

Iron draws or attracts electricity, and thus the iron lightning-rod conducts the lightning away from the house to itself.

What becomes of the lightning then?

The rod leads or conducts it down into the ground, and prevents it from doing any harm.

Is there any thing that electricity will not pass through?

It will not pass through glass, ivory, silk. gutta percha, and several other substances.

Then how should a lightning-rod be fastened to the house to keep it from going off the rod, and injuring the house?

It should be fastened by something that does not conduct electricity

In what other way can you see the EFFECT *of electricity, or what electricity does?*

If I take a cat into a dry, dark room, and rub the fur on her back with a piece of silk, I shall see sparks of light, and hear them crackle.

Why do you use silk?

Because silk keeps the electricity, caused by rubbing, from going off to my hand.

Then rubbing or FRICTION *can produce electricity, can it not?*

Yes; all bodies may be made to produce electricity by *friction.*

If you take a dry and warm glass rod and rub it with silk, why will it attract bits of paper and feathers to itself?

Because the friction or rubbing has excited a different electricity in the glass from what is in the paper or feathers.

Why do they instantly drop off?

Because, when they touch, they are brought into the same state of electricity, and the attraction ceases.

What remarkable stone can you mention?

There is one which attracts iron and steel, called *lodestone*, and also *magnet*, from Magnesia, where it was found.

What happens if you rub this lodestone upon iron or steel?

It gives magnetism to them, and they will also attract needles or little pieces of steel to themselves.

Does the earth seem to have more magnetism in one part than in another?

It does.

What part has the greatest magnetism?

That near the north pole.

Of what use is that magnetic attraction to us?

If a needle be *magnetized*, or rubbed with a lodestone, and placed where it can turn easily, one end will point toward the north.

Why will it?

Because the magnetism of the earth, near the north pole, is so great that it draws that end of the needle.

Then how is it useful to us?

It shows us which way is north, when we are traveling or sailing.

What little INSTRUMENT *or* MACHINE *do sea-captains have to tell them the way to sail their ships?*

They have such a needle fixed loosely in a little box, with a glass cover to it, and by looking at this needle they can see which way they are sailing.

What is the name of this useful little instrument?

It is called the *mariner's compass.*

What toys are made for children, to show magnetism?

Sometimes little tin boats are made, with a steel wire at one end, and the boat will float in a basin of water.

How can the boat be made to move?

I can take the little wire magnet that comes with such boats, and, if I point it toward the steel wire at the end of the boat, it will move toward my magnet, and so I can draw it all around the basin.

Are there any other such toys?

Sometimes little glass ducks and fishes are made with a bit of steel in their mouths, and they will be drawn to the magnet in my hand in the same way.

Lesson Thirty-First.

You *told me that all bodies may be made to produce electricity by friction; can electricity be produced in any other way?*

It can, by means of metals and a peculiar liquid called an *acid.*

Can you explain how it is done?

When certain different kinds of metals are put into an acid, and then these metals are connected by a wire, a peculiar kind of electricity will be made to pass along the wire, from one metal to the other.

How long will this electricity continue to pass?

As long as the metals remain in the acid and are connected by the wire.

How long may the wire be which connects the metals and carries the electricity?

As long as we choose to make it.

Which way would the electricity move?

It could go either way, though not at the same instant.

How could the electricity be kept from passing off from the wire?

By covering the wire with gutta percha, or something that does *not* conduct electricity.

How could it be stopped in passing along the wire?

By putting to it another wire, or any thing that conducts electricity, or by cutting the wire.

Where do we see such wires?

The telegraph wires that we see fastened to tall posts are such wires.

Where are the ends of these wires?

One end of the wire is generally in a house

in some large city, like New York, and the other in another city, like Washington or Boston.

How fast does the electricity go from one end of the wire to the other?

It seems to take no time; but the instant it starts it seems to be at the other end.

What wonderful instrument is fixed at each end of the telegraph wire?

Mr. Morse has contrived an instrument to make marks by means of the electricity.

What is the use of these marks?

Each mark stands for some letter of the alphabet.

What is done with these marks?

Some one writes out the letters they stand for on a piece of paper, thus:—

— - —— ——   —-—- - - - - - - —-

T e l l   J o h n.

Of what use is all this?

A person at the instrument, in New York,

can make the electricity pass along the wire to the Washington instrument, and scratch the letter-marks on the paper there.

Then what will be done in Washington?

The person at the instrument there will read the words, and then send back electricity along the wire, which will write his answer in the office in New York.

What more wonderful instrument has Mr. House made?

He has made an instrument that prints the *letters* themselves.

What does it look like?

It looks a little like a piano, with a small machine on the top of it.

How is it used?

A gentleman sits before it, as if he were playing the piano. As he touches the ivory keys, the electricity passes along the wire to Washington, and the instrument *there* begins to print the letters that each key makes.

What are these letters printed upon?

They are printed upon a narrow strip of paper, that rolls off a little wheel as fast as it is wanted.

What is done with this strip of paper?

It is cut off, and sent wherever it is directed; and then the instrument is ready for another message.

Why is this way of writing letters to people very convenient?

Because people can talk together about their business, without losing any time, just as if they were in the same room.

Are there many telegraph wires?

Yes; all the large cities have them.

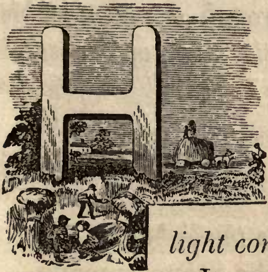
What was the most wonderful telegraph wire ever made?

The one that stretched across the Atlantic ocean.

Are there telegraph wires in other countries?

There are; and the time may come when people in every part of the world can talk together, by means of them.

Lesson Thirty-Second.



How *high from the earth does the atmosphere extend?*

More than forty-five miles.

From what does all our light come?

It comes from the sun.

When the rays of light, in coming from the sun, enter the atmosphere, what happens to them?

They are refracted or broken, and turned out of their course.

What refracts them?

The atmosphere.

Does it also separate the light into different colors, like the prism?

It does not; it only breaks them.

If the atmosphere becomes more DENSE *or* THICK, *how would the light be refracted?*

It would be refracted more and more, the more dense the atmosphere becomes.

When light passes through a prism, which colored ray is refracted the most, or turned the furthest out of its course?

The violet.

Which is refracted the least?

The red.

What is it that refracts the light?

The glass, of which the prism is made.

If light passes through water, is it refracted more or less than when it passes through the atmosphere?

It is refracted more.

Why does water refract light more than the atmosphere?

Because it is more dense than air.

Then what bodies refract light most?

The densest bodies through which light can pass refract it most.

Why does the sky or atmosphere look blue?

The rays of light come from the sun, pass through the atmosphere to the earth, and are reflected back through the atmosphere, and the *blue* rays are stopped on their way, and reflected again to our eyes.

What becomes of the other colors?

They pass on through, without being reflected.

Why are the blue rays stopped?

Because they do not seem to have momentum enough to carry them through.

What did you say was the meaning of MOMENTUM?

Moving *power;* or weight and speed put together.

Then what do you mean by the momentum of a blue ray?

Its power to carry itself through the atmosphere.

Which color has the greatest momentum?

The red.

If the atmosphere should become very thick or dense, what would be the effect upon the light that passes through it?

None of the rays but the *red* would have momentum enough to pass through the atmosphere.

When does the sun look red?

When it is seen through a fog or vapor.

If the atmosphere did not reflect any of the sun's rays, how would the sky appear?

Perfectly black.

When bodies do not allow any light to pass through them, what do we call such bodies?

Opaque bodies.

Can you mention an opaque body?

A piece of wood, or marble, or iron, is opaque.

How can you tell?

By holding them up, to see whether the light will pass through them.

When a body permits light to pass through it, what kind of a body is it called?

A *transparent* body.

Will you mention some transparent body?

Glass is transparent.

Why is it transparent?

Because light can pass through it.

Is water transparent?

It is.

Then why is it more difficult to see bodies distinctly through a fog than when the air is clear?

The fog refracts these rays of light that bodies reflect through it so much more than air does, that we can not distinguish the size and shape of those bodies very well; they seem much larger than they really are.

Can you relate a story about a singular mistake caused by a dense fog or mist?

A shepherd, upon one of the Cumberland mountains, in Europe, was suddenly surrounded with a thick fog. Every thing seemed so very large that he lost his way. He tried to find some object that he knew,

and by which he could find where he was, and where he ought to go. He soon came to what seemed to be a very large mansion, which he did not remember of having seen before. He went into it to inquire the way home, and there found his own family. It was his own cottage. The fog had deceived him so much that it was some time before he could believe the fact.

Do clouds ever reflect shadows of objects that are before them?

They do.

Will you mention one instance?

Many years ago, a Mr. Hane went up the Hartz mountains, in Germany, at a place called the Brocken. As he looked toward the south-west, he saw, at a very great distance, the figure of a man as large as a giant. Just then a gust of wind almost blew off his hat, and he raised his hand to his head to keep on his hat. The figure did the same. He then bent his body, as if to salute it The

figure returned it at the same instant. He then went back, and took another man with him. They then saw two such giant figures; and all that these men did, the figures imitated.

What was the cause of this appearance?

When the sun is rising or setting, and throws his rays over the Brocken, upon the fine, light clouds floating around, if a man comes between the rays of light and the cloud, the shadow of the man will be seen on the clouds opposite him, and all his motions will be represented by his shadow.

How large will his shadow be?

It may extend *five or six hundred feet.*

How far from the man will it be?

Two miles off.

What name have the people in that country given to this immense shadow?

They call it the *Specter of the Brocken.*

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